Financial analysis of the impact of dioxin crisis and of the current surveillance system in the Dutch dairy chain

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Summary

Background

Food safety can be disturbed by microbiological, physical and chemical agents (De Meulenaer, 2006). As part of the chemical agents, environmental pollutants which include several inorganic and organic compounds are important causes of food contamination (De Meulenaer, 2006). Dioxins, as part of the "dirty dozen" or best known as persistent organic pollutants (WHO, 2007b), are one of the most salient environmental contaminants and cause of problems of the last decades (Hoogenboom et al., 2004). One of the most important dioxin crises occurred in Belgium in 1999, where increased levels of dioxins and PCBs, as compared to the maximum established limits, were found in eggs, poultry and pork products. The cause was the use of animal feed contaminated with PCB waste industrial oil (Huwe and Smith, 2005; Buzby and Chandran, 2003; Lok and Powel, 2000). Dioxin crises are not only a threat for human health, but also for the economy of the country, specifically for the agri-food chains involved. Control measures taken during a crises, for example, a temporary block of production facilities (Valeeva et al., 2006) or the recall of products from the market, have direct costs and losses for companies (Velthuis et al., 2009), affecting internal and external business relationships. The Belgian crisis in 1999 affected to a large extent the agricultural sector in this country at the internal and external level because of the temporal disruption of commercial relations with more than 30 countries worldwide (Buzby and Chandran, 2003).

Objectives

The general research objective is: *To quantify the financial impact of a dioxin crisis in the Dutch dairy chain, considering costs and benefits of the current surveillance system.* Specific research objectives are: a) *To estimate the financial consequences of a dioxin incident over the agri-food businesses, members of the Dutch dairy chain,* and b) *To estimate the costs of the current surveillance system for dioxins as well as the benefits in terms of reduced impact of a dioxin outbreak.*

Methodology

The Dutch dairy chain consists of five main stages: feed supplier, farmer, processor, retailer (exporter) and consumer. The Milk Dioxin Contamination Impact Model (MDCIM) takes into consideration the four first stages of the chain in order to analyze the economical impact of a dioxin contamination on the entire chain.

The information used as input of the MDCIM has been obtained based on relevant literature regarding the Dutch dioxin incident of 2004 (included in chapter 2), and expert knowledge (obtained by interviews). Additional information required by the MDCIM model as input which was not available from the previous sources, has been based on assumptions.

The control measures taken into consideration in this model are divided by group of activities which are applied when the dioxin incident is identified. They are: 1) Diagnostic, 2) Blocking, 3) Recall and 4) Destruction activities.

The calculation of the economical impact of a dioxin incident in the MDCIM model is based on a partial budgeting approach which is related to the calculation of the negative effects of the dioxin incident (extra costs and returns forgone) and it´s positive effects (additional returns and reduced costs). The sensitivity analysis carried out to analyze the effect of the selected inputs on the total economical impact obtained by the MDCIM model is based on a univariate analysis. There are 2 scenarios considered based on the number of feed and food businesses involved in the incident: 1) Scenario 0 which include only one feed or food business in each stage of the chain, 2) Scenario 1 which is composed of 1 feed supplier, 75 dairy farms, 3 milk processor and 189 retailers.

Results

Economical impact for the entire food chain and for each chain stage

The total economical impact for the entire dairy chain is accounted to be € 3´022.713 of extra costs and returns forgone obtained in Scenario 0 (SC0) and including the Risk Analysis costs. If these costs are not considered, the total economical impact in the entire chain is accounted on €3´019.713, which is divided in: 1) €1`716.742 (56,85%) per a feed supplier production site, 2) €38.078 (1,26%) per a dairy farm, 3) €1`260.375 (41,74%) per milk processor production site and 4) €4.518 (0,15%) per retailer site.

Economical impact per group of activities

From the total economical impact, the destruction activities are the most important cost contributors for the entire chain. They are accounted on €2´051.569 (67,94%) of the total economical impact. They are followed by the recall activities which are accounted on €811.011 (28,56%) of the total economical impact. Blocking activities (€49.473; 1,64%) and Diagnostic activities (€52.660; 1,74%) are the less important cost contributors for the total economical impact in the occurrence of a dioxin incident.

Sensitivity analysis SC1

From the results of the sensitivity analysis SC1, only the inputs which could affect in more or less than 1% are discussed in this chapter. The results of the sensitivity analysis show that: 1) an increase or reduction of 10% in the sales prices of consumption milk and the amount of consumption milk recalled at the milk processor level, could increase or reduce the total impact in more than 3%. Different than the result obtained in the sensitivity analysis at SC0, the amount of milk produce and the blocking time at farmer level show a high influence of more than 2% but less than 3% on the total impact.

Scenario analysis:

Although the main contributors to the total economical impact in SC0 are the feed supplier and milk processor stages, after the third day of contamination, it is shown that the contribution of the feed supplier is going to reduced along the time (from 64,33% to 5,11%), while the contribution of the milk processor remain almost in the same percentage (around 45%). At the same time, the contribution of farmer after the same day is located between 35 and 40% while, the contribution of the retailer remain stable at the same proportion (10%)

Conclusions

The objective of this research is to estimate the financial consequences of a dioxin incident over the agri-food businesses more specifically members of the Dutch dairy chain.

The main conclusions of this study are:

1) The total economical impact of a dioxin incident strongly relates to the proportion of feed and food businesses involved.

2) The milk processor followed by the dairy farmer contributes the most to the total economical impact of the contamination.

3) The destruction activities and the recall activities are the most important contributors to the total impact value

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CHAPTER 1: INTRODUCTION

1.1 Problem definition

As a result of the radical change in orientation, from production to consumption, that agricultural and food markets have experienced in the last decades, companies in agribusiness and food industry are nowadays consumer oriented (Knura et al., 2006). In this respect, the increasing demand for safe food products as one of the main food quality attributes required by consumers, is a salient issue for food business operators. Coordinated actions integrating all stages of a food chain ("from farm to table") (Valeeva et al., 2006) are required to guarantee as much as possible food safety to consumers and prevent from food safety incidents. At the same time, these actions are important to react quickly once food safety incidents (crises) have occurred, aiming to reduce their negative (economic) impact on all of the members of the agri-food chain.

Just after the mid 1970's, food safety had become an important subject for scientists, politicians and society in general (Cooter and Fulton, 2001; Knowles et al., 2007). This is mainly because, before this time, food was considered safe (Cooter and Fulton, 2001). From the mid 1980's onwards, the occurrence of several food safety incidents in most Western European countries (i.e. BSE, E-Coli, Salmonella, Dioxin residues) (Knowles et al, 2007) increased the awareness of consumers of being exposed to food borne illnesses. Indeed, the WHO (2007a) estimated the percentage of population affected by food borne diseases in industrialized countries to be up to 30% per year. Consequently, the various stakeholders (i.e. consumers, scientists and politicians) increasingly demand safer food.

Food safety can be disturbed by microbiological, physical and chemical agents (De Meulenaer, 2006). As part of the chemical agents, environmental pollutants which include several inorganic and organic compounds are important causes of food contamination (De Meulenaer, 2006). These compounds, produced by natural and industrial processes (WHO, 2007), are emitted to the environment contaminating agricultural products and, hence, food products (De Meulenaer, 2006). Dioxins, as part of the "dirty dozen" or best known as persistent organic pollutants (WHO, 2007b), are one of the most salient environmental contaminants and cause of problems of the last decades (Hoogenboom et al., 2004). Their importance is based on: 1) their high level of toxicity affecting different human systems and organs, and 2) their properties of stability and accumulation in fat tissue and in the different stages of the agri-food chain (WHO, 2007b).

As compared to data of 1970, the level of dioxins such as polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) and dioxin-like compounds such as polychlorinated biphenyls (PCBs) in breast milk are 3 to 5 times lower than at present (WHO, 2007c). However, the human dietary intake of dioxins and dioxin-like polychlorinated biphenyls (PCBs) is still above the exposure limit of 14 pg TEQ/kg bw/week in a significant proportion of the European population (SCF, 2001; EC, 2006a; Hoogenboom et al., 2005; Behnisch, 2005). It is argued that milk and other dairy products as well as fish, meat and meat products are the main contributors of the diet of the European citizens to exposure to these compounds (WHO, 2007b). The impact of the various contributors may be different during food crises due to higher levels of dioxins found in specific products (EC, 2000).

Literature reports an important number of incidents due to high levels of dioxins found in food (WHO, 2007b). The main source of these incidents was the use of contaminated feed ingredients (Huwe and Smith, 2005). One of the most important dioxin crises occurred in Belgium in 1999, where increased levels of dioxins and PCBs, as compared to the maximum established limits, were found in eggs, poultry and pork products. The cause was the use of animal feed contaminated with PCB waste industrial oil (Huwe and Smith, 2005; Buzby and Chandran, 2003; Lok and Powel, 2000). A few years later (2004), increased levels of dioxins were found in milk of a dairy farm, during a routine test in The Netherlands. The source of this incident was the use of potato industry by-products as animal feed contaminated with dioxin-containing kaolinic clay (LNV, 2004, Hoogenboom et al., 2009). Previous to the 1999 and 2004 incidents, namely in 1996, the US food safety authority determined that ball clay used as feed for poultry and catfish was the source of dioxin contamination of fish and chicken derived products, and prohibited its future use as in feed (Hoogenboom, 2004). Two years later (1998) another important incident occurred in The Netherlands and Germany where milk, butter and meat samples show increased levels of dioxins. The source of this incident was the use of contaminated citrus pulp (imported from Brazil) as a feed ingredient for ruminant feed (Malisch, 2000; Hoogenboom, 2004).

Dioxin crises are not only a threat for human health, but also for the economy of the country, specifically for the agri-food chains involved. Control measures taken during a crises, for example, a temporary block of production facilities (Valeeva et al., 2006) or the recall of products from the market, have direct costs and losses for companies (Velthuis et al., 2009), affecting internal and external business relationships. The Belgian crisis in 1999 affected to a large extent the agricultural sector in this country at the internal and external level because of the temporal disruption of commercial relations with more than 30 countries worldwide (Buzby and Chandran, 2003).

An early identification of the presence of possible contaminants is crucial when trying to reduce all negative consequences of the latter. In this regard, regulations of maximum, action and target levels as well as surveillance monitoring programs in food and feed have been implemented by local governments and at European Union level (EC, 2001; EC 2006; Buzby and Chandran, 2003). These programs aim to reduce the intake and to prevent future crises by identifying points of contamination in the feed and food chain and their sources (Hoogenboom, 2005).

Incidents identified by positive results of surveillance monitoring assays are confronted with predefined control measures applied by local governmental institutions. However, there is a lack of knowledge regarding the economic damages on the members of the agri-food chains caused by the occurrence of a dioxin incident and the application of control measures. Previous research assessed the impact of a feed crisis in different stages of the food chains (Meuwissen et al., 2009; Meuwissen et al., 2008) and another pursued to estimate the direct recall cost in the Dutch milk chain (Velthuis et al., 2009). Nevertheless, none of them considers the impact of a crisis on the entire food chain nor is focused on specific dioxin incidents. The aim of the current study is to estimate: 1) the financial consequences of an food safety crisis on the involved and affected members of the food chain and 2) the financial analysis of the current surveillance system.
As a case study, the current research focused on the dioxin incident of 2004 in the Dutch dairy production chain (Hoogenboom, 2004), and considered the primary and processing stage of this chain. This case was considered very relevant due to the high level of production and consumption of milk and dairy products in The Netherlands. Also, these dairy products are a high source of dioxin contamination.

1.2 Research objective

The general research objective is:

- To quantify the financial impact of a dioxin crisis in the Dutch dairy chain, considering costs and benefits of the current surveillance system.

More specific research objectives are:

a) To estimate the financial consequences of a dioxin incident over the agri-food businesses, members of the Dutch dairy chain.

b) To estimate the costs of the current surveillance system for dioxins as well as the benefits in terms of reduced impact of a dioxin outbreak.

1.3 Research questions

The research objectives were translated into the following research questions:

1. What is the financial impact of a dioxin crisis on the Dutch dairy chain?
   - What are the control measures taken during the dioxin crisis?
   - Who are the stakeholders involved and affected by this control measures?
   - What are the direct or indirect and the negative or positive effects of measures taken during the crisis?
   - What is the financial impact of the control measures on the dairy chain and in each member of the Dutch dairy chain?

2. What are the benefits of the current surveillance system for dioxins regarding the reduction of the impact of a dioxin crisis in the Dutch dairy chain?

3. What are the costs of the current surveillance system for dioxins applied in the dairy chain in The Netherlands?

1.4 Outline of the research

A review of the most important dioxin crises and incidents occurred in the Western European countries and The United States, a detailed description of the organizational structure of the Dutch dairy chain, and an explanation of the current dioxin surveillance system in The Netherlands are given in chapter 2. The methodology and materials used to carry out this study are depicted in chapter 3. The developed model, including a description of the economic analysis performed in the research is included in chapter 4. In the same chapter the results of the study, detailing the outcomes found regarding the total economic impact of a dioxin crisis and its distribution throughout the members of the dairy chain are depicted as well. In the last chapter (5), the main conclusions are delineated followed by a discussion (about the findings and methodology) and propositions for further research.

CHAPTER 2: LITERATURE REVIEW

In the following chapter, a detailed explanation of dioxins and dioxin-like compounds with regard to their composition, sources, effects on human and animal health and legal regulations are depicted. In addition, the major food dioxin incidents and crises worldwide are described with emphasis on the Dutch 2004 incident and the control measures taken to confront it.

2.1 Dioxins and dioxin-like PCBs

Dioxins are unwanted by-products of manufacturing processes (WHO, 2007b) and combustion processes (Behnisch, 2005). As such, they are dangerous environmental pollutants produced by both industrial and natural processes (WHO, 2007b). Although volcanic eruptions and forest fires are natural sources of dioxins, the latter are mainly produced and released into the environment by industrial processes (WHO, 2007b).

Dioxins include two kinds of chemical compounds: polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) (De Meulenaer, 2006; Hoogenboom, draft). Additionally, although coming from a different source, but because of their similar chemical structure and toxic properties (WHO, 2007b), polychlorinated biphenyls (PCBs) are also included in this group as dioxin-like compounds (De Meulenaer, 2006).

Depending on the degree and place of chlorination, there are different types (congeners) of PCDDs, PCDFs and PCBs (De Meulenaer, 2006). In total, there are 75 PCDD congeners, 135 PCDF congeners and 209 PCB congeners. Of these, only 7 PCDDs, 10 PCDFs and 12 PCBs are considered toxically relevant (De Meulenaer, 2006). Moreover, as there are specific congener patterns produced depending on the source of the dioxins, they can be used to trace and identify the source of the latter (Hoogenboom, draft).

Dioxins are formed as a result of the production of organo chlorine compounds (pesticides and herbicides) (WHO, 2007b). Moreover, they are released during bleaching processes in which chlorine is used, such as that to bleach wood pulp (De Meulenaer, 2006). In addition, various types of combustion processes, from cigarette smoke to incineration processes (in presence of chlorine compounds), are also sources of dioxins

(De Meulenaer, 2006). Nowadays in Europe, waste incinerators (solid waste and hospital waste), facilities of iron, steel industry and the non-ferrous metal industry, are the major industrial sources of dioxins emitted to the environment (Quass et al., 2000; Behnisch, 2005; Van Larebeke et al., 2001).

While dioxins are produced unintentionally, dioxin-like compounds such as PCBs are produced industrially (De Meulenaer, 2006). PCBs are oil-like fluids which result from the chlorination of biphenyl which, depending on its concentration, generates different products with different applications (Safe, 1994). They were intensively used as organic diluents, plasticizers, flame retardants, heat transfer fluids, dielectric fluids for transformers and capacitors, hydraulic lubricants, etc. (Safe, 1994; De Meulenaer, 2006; Hoogenboom, draft). However, since 1979, the industrial production of PCBs was prohibited in industrialized countries because of their toxicity and persistence in the environment (De Meulenaer, 2006). Although PCBs are not currently produced, their use is not forbidden (Hoogenboom, draft), and can be found in old industrial facilities (De Meulenaer, 2006). Therefore, nowadays, adequate disposal practices need to be applied to manage these products and are of great concern in order to avoid their introduction and persistence in the environment.

2.2 Effects of dioxins and dioxin-like compounds on animal and human health

Since dioxins and dioxin-like compounds are resistant in the metabolism and accumulate in fat tissue (Lok and Powel, 2000), they have distinct toxic effects on human and animal health (WHO, 2007b). These compounds have proved an effect as endocrine disruptors at the sexual development and thyroid levels (Hoogenboom, draft) and may cause immunotoxicity, neurological disorders, cloracne, teratogenic and carcinogenic effects (De Meulenaer, 2006). Indeed, the International Agency for Research on Cancer (IARC), in 1997, reclassified the 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) to the first group (group 1) of human carcinogenic compounds (Hayward et al., 1999). Animals in laboratories which are exposed to TCDD, develop liver tumors and at lower levels of exposure, immunological and reproductive alterations (Hoogenboom, draft). In line with this, humans who are accidentally exposed to these compounds show a major risk of developing diabetes and cancer (Hoogenboom, draft). Although the individual effects of these compounds on human health are known, the human exposure to a mixture of dioxins and dioxin-like PCBs is still unknown and, overall, makes their real toxics effects still difficult to acknowledge (Hoogenboom, draft).

2.3 Contamination route towards human exposure

Dioxins have a chemical and biochemical resistance to degradation with bioaccumulation, biomagnification (De Meulenaer, 2006; Lok and Powel, 2000) and semi-volatility properties (Behnisch, 2005). Consequently, they can be: 1) kept stable and persistent in the environment and in the organism; 2) accumulated and magnified when moving up in different stages of the food chain (WHO, 2007b; Lok and Powel, 2000) and; 3) moved beyond country borders (Behnisch, 2005). In this regard, it is not only the environment, but also the food, which could be the route of access of these compounds to the human body (Hoogenboom, draft; Hayward et al., 1999) and ,in fact, nowadays, food is the most salient contributor to dioxin contamination (Hoogenboom, draft). This has been proven by a study by Buzby and Chandran (2003) which argued that of all possible sources of human exposure to dioxins, an 80 to 95% of it comes from the food chain. According to WHO (2007b), dairy and meat products including fish and shellfish are the products in which these compounds have been found in highest levels as compared to food products of vegetable origin. So, these are considered the main suppliers of dioxins to the human daily intake (Hoogenboom, draft) as have been involved in most food contamination incidents. The presence of dioxins in these types of products is linked to the existence of dioxins in earlier stages of the agri-food chain. It is the use of contaminated feed ingredients and other contaminated products used as feed materials that are major sources of dioxin contamination of animal food products.

2.4 EU Regulations regarding human exposure to dioxins

Due to the food and feed dioxin contaminations which occurred before 1999, and specifically as a result of the Belgian dioxin crisis occurred in that same year, European authorities acknowledged a lack of legislation at Community level with regard to dioxin levels in food and feed (Verstraete, 2002). Consequently, in 2000, and based on reports made by the EU´s Standing Committee on Animal Agriculture and Nutrition (SCAN) and the Scientific Food Committee (SFC), a maximum human exposure limit was established as a provisional tolerable weekly intake (pTWI) of 14pg TEQ/kg bw for dioxins and dioxin-like PCBs (EC, 2000; SFC, 2001; Verstraete, 2002; Buzby and Chandran, 2003; Hoogenboom, 2005; 2009). In addition, based on the conclusions reported by previous studies, the European Commission (EC) decided to set standards regarding the levels of contaminants in food and feed. These standards are part of a complete strategy to pursue the reduction of the levels of dioxins in the environment, feed and food (EC, 2001).

The strategy consists of two parts. The first part aims to establish actions at short, medium and long term in order to obtain more information about dioxins (identify dioxins sources and trends) and entry points into the food chain (Hoogenboom et al., 2009) to support future policies (Buzby and Chandran, 2003). The second part pursues to set maximum, action and target levels of dioxins in feed and food in order to set a legal framework in which authorities could make decisions when facing new incidents, and to keep a constant reduction of existing levels (Buzby and Chandran, 2003).

Maximum levels of dioxins and dioxin-like PCBs in food and feed were published in the Commission Regulation No. 466/2001 and Commission Directive 2002/32, respectively. However, given the limited information regarding PCBs and their contribution to the total dioxin Toxic Equivalent (TEQ), since 2004 and until 2006, a permanent monitoring program was implemented for PCBs in food and feed in most European countries. This program pursued to include the contribution of PCBs into the total TEQ (Behnisch, 2005). In this regard, and based on increasing concerns about the effects of dioxins on human health as a result of a long-term consumption of high levels of dioxin containing food (Gruemping, 2006), the EC, in 2006, enacted new maximum levels of dioxin and dioxin-like PCBs in food (Commission Regulation No. 199/2006) and feed stuffs (Commission Directive 2006/13). Nowadays, these are the currently applied legislations at EU level.

New regulations aim to reduce the human exposure of dioxins and dioxin-like PCBs, as there is a small or non-existent distance between the current exposure and the exposure limit in at least part of the European population (Hoogenboom, draft). Moreover, new hazardous compounds such as those derived from brominated flame retardants showing similar adverse effects to dioxins represent new sources of exposure (Hoogenboom, draft). The contribution of these compounds to the human daily intake and to the total TEQ of dioxins and dioxin-like compounds is still unknown and there are no exposure limits established. Consequently, new regulations and further research is expected from European authorities in order to deal with the existent exposure levels and new dioxin-like compounds. Table 1 presents the maximum levels of dioxins and dioxin-like PCBs in food, based on the EC Commission Regulation No. 199/2006 (EC, 2006b).

Table 1. Maximum levels of dioxin and dioxin-like PCBs in food (Adapted from Reg (EC) 199/2006)

Food stuff	**Maximum levels Sum of dioxins and furans (WHO-PCDD/F-TEQ)**	**Maximum levels Sum of dioxins, furans and dioxin-like PCBs (WHO-PCDD/F-PCB-TEQ)**
Meat, meat products and animal fat: 1. Ruminants (bovine animals and sheep) 2. Poultry and farmed game 3. Pigs	 1. 3 pg/g fat 2. 2 pg/g fat 3. 1 pg/g fat	 1. 4.5 pg/g fat 2. 4 pg/g fat 3. 1.5 pg/g fat
Liver of terrestrial animals and derived products	6 pg/g fat	12 pg/g fat
Muscle meat of fish and fishery products	4 pg/g fresh weight	8 pg/g fresh weight
Muscle meat of eel and eel products	4 pg/g fresh weight	8 pg/g fresh weight
Milk and milk products including butter fat	3 pg/g fat	6 pg/g fat
Hen eggs and egg products	3 pg/g fat	6 pg/g fat
Mixed animal fat	2 pg/g fat	3 pg/g fat
Vegetable oil and fat	0.75 pg/g fat	1.5 pg/g fat
Marine oil for human consumption	10 pg/g fat	10 pg/g fat

2.5 Dioxin food-contamination incidents and crises worldwide

Although food incidents and food crises are both used to describe food contamination events, their differences rely on: 1) the time in which the food contamination is identified; 2) the size of the contamination and their consequences and; 3) the applicability or not of pre-defined measures in order to control the event. Food crises consist of non-predictable, unstable and disordered sequences of events with large scale effects and in which pre-established control models are not longer applicable (EFSA, 2004). In Table 2 (next page), worldwide incidents and crisis related to food dioxin contamination are depicted.

In the following subsections, a few of the dioxin food-contamination incidents depicted in Table 2 will be described focusing on their impact on human health and the economy. A more detailed explanation of the Belgian dioxin crisis of 1999 and the Dutch dioxin incident of 2004 will be given. The reason for this more in depth explanation is, firstly, because of the enormous social, economical and political consequences of the Belgian crisis. Moreover, the information gathered from the Dutch dioxin crisis was used to design the Milk Dioxin Contamination Impact Model which will be shown in Chapter 4.

Table 2. Incidents and crisis related to food dioxin contamination worldwide (adapted from Benisch, 2005)

Year	Description of the incident/crisis	Country
1958	Chicken edema factor	USA
1968/1979	Contaminated rice oil	Japan/Taiwan
1982	Contaminated olive oil	Spain
1996	Feed compounds contaminated by ball clay	USA
1998	Improper drying of feed (Citrus pellets)	Brazil
1999	Illegal disposal of capacitor fluids	Belgium
1999	Improper drying of feed (Green garbage)	Germany
1999	Sewage sludge in feed premixes	France
2000	Choline chloride: Pentachloropenol (PCP)-contaminated sawdust	Spain
2001	Incinerator dust on spinach	Japan
2002	Carbosan copper as feed premix	France, USA
2003	Bakery waste contaminated by wood waste	Germany, The Netherlands
2004	Potato by products contaminated by kaolinic clay	Germany, The Netherlands, Belgium

2.5.1 United States (US) dioxin incident in 1996: The case of contaminated ball clay use as feed additive.

Increased levels of dioxins (specifically 2,3,7,8-TCDD) were found in chicken samples during a national survey conducted in the United States in 1996 (Hayward et al., 1999). The cause of these unusual levels of dioxins was found to be the use of contaminated animal feed. The source of this contamination was the use of soybean consisting of an anti-caking agent called "ball clay" (Hayward, 1998), originally found in mines of the southern part of the USA (Hayward, 1998; FDA, 1997). Ball clay is also used as feed additive in complete feeds and in other feed components (FDA, 1997). Further research concluded that not only chicken, but also eggs and farm-raised catfish, were contaminated due to the same cause (Hayward et al., 1999). Consequently: 1) contaminated soybean as well as contaminated feed was withdrawn from the market; 2) chicken and catfish producers destroyed animals exposed to contaminated feed and; 3) catfish and eggs exposed to ball clay were banned until levels of contamination were determined (Hayward et al., 1999).

Further research carried out by the Food and Drugs Administration (FDA), the Environmental Protection Agency (EPA) and the Food Safety Inspection Service of the USDA determined that ball clay obtained from different mines inside the US had high levels of dioxins. Therefore, since then, its use in the production of compound feed and feed ingredients was prohibited (FDA, 1997).

2.5.2 German incident of 2003: The case of contaminated bakery waste used in animal feed

Although dioxin-contaminated pigs were identified in The Netherlands in 2003, the impact of this incident in the Dutch food chain was limited in its extension (Hoogenboom et al., 2005). This is in part because of a rapid alert issued by the EU and the quick response of the Dutch food safety authority regarding the identification of possible contaminated products. In total, there were 339 samples taken of bread meal, feed, and animal fat during 3 weeks with the aim of determining the dioxin levels in feed and food (Hoogenboom et al., 2005).

The cause of this contamination was dioxin-contaminated bakery waste coming from Germany, used as feed ingredient in different kinds of feed compounds. It is argued that its contamination was due to the use of waste wood during the drying process of the bread meal (Hoogenboom et al., 2005).

2.5.3 The Belgian dioxin crisis of 1999

Described in literature as an unprecedented food dioxin crisis (Bernard et al., 2002), the Belgian dioxin crisis which started in January of 1999, was the result of feed contamination with dioxins and dioxin-like PCBs (Bernard et al., 2002; Buzby and Chandran, 2003). A scheme designed by Covaci and co-authors (2008) with the chronological evolution of the Belgian crisis of 1999 is sketched in Figure 1 below.

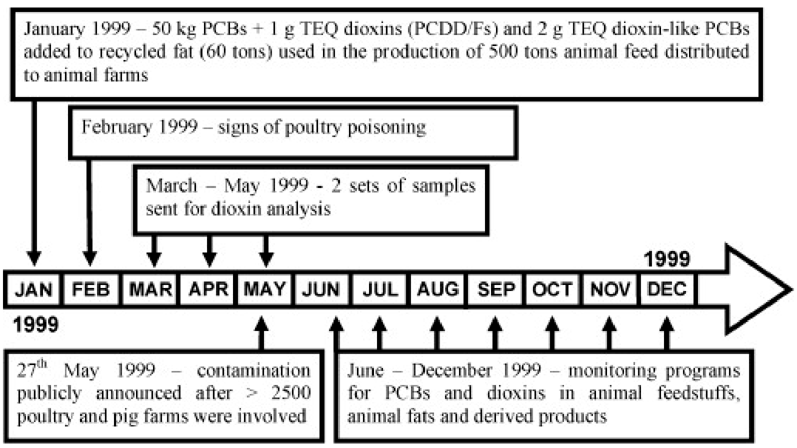

Figure 1. Chronological order of the events in the Belgian dioxin crisis of 1999 (Covaci et al., 2008)

Although the exact source of the contamination was not sufficiently clarified by Belgian authorities (Lok and Powel, 2000; Buzby and Chandran, 2003), different authors agree that it was the mixture of mineral oil of old discarded transformers (containing PCBs and dioxins) with recycled animal fat (Bernard et al., 2002; van Larebeke et al., 2001; Lok and Powel, 2000).

This contaminated fat was then used in feed production, mainly by Belgian feed manufactures, but also, although to a lower extent, by French, German and Dutch feed producers (Lok and Powel, 2000; Van Larebeke et al., 2001). The impact of this starting point of the contamination was quite severe. Namely, from 10 feed producers only in Belgium, 500 tons of contaminated feed were delivered to 445 poultry farms, 746 pig farms, 237 dairy farms and 393 bovine farms (Van Larebeke et al., 2001; Buzby and Chandran, 2003). Consequently, increased levels of dioxins and dioxin-like PCBs were found in eggs, poultry and other poultry derived products as well as pork, dairy and beef products (Buzby and Chandran, 2003; Van Larebeke et al., 2001).

Control measures such as preventive and curative actions including product recalls, animal sacrifices, and blocked food businesses (at primary production and processing level) were taken by Belgian authorities in order to solve the crisis (Lok and Powel, 2000). However, the crisis was only solved when implementing a food monitoring program for PCBs and dioxins on a large scale. In this program, more than 55000 PCBs and 500 dioxins analysis were carried out and accounted until December 1999 (Bernard et al., 2002; Covaci et al., 2008). The amount of animals and animal food products contaminated due to this crisis is still uncertain (Van Larebeke et al., 2001).

2.5.3.1 Human health impact

In line with the study of Van Larebeke and co-authors (2001), as a result of the crisis and in a supposed worst case scenario: 25000 ng of PCBs and 500 pg of international TEQ dioxins were the mean intake per kilogram of body weight for 10 million Belgians (Van Larebeke, et al., 2001). This resulted in between 40 and 8000 cancer deaths due to this event (Van Larebeke, et al., 2001). Other diseases apart from cancer such as those related to disorders of neurological and endocrine functions found in neonates, infants and children can also be linked with the occurrence of this event (Van Larebeke et al., 2001). Nevertheless, conclusive results in this respect have not been reported.

2.5.3.2 Political and economical impact

Although symptoms of contamination were detected in February 1999 (Bernard et al., 2002), and higher levels of dioxins were confirmed in April 1999, Belgian authorities did not make a public announcement of the dioxin contamination incident until the end of May 1999 (Lock and Powel, 2000). This omission had political and economical consequences both inside and outside Belgium.

The image of the Belgian government was negatively affected both nationally and internationally as it showed a lack of transparency when dealing with the problem and no consideration for possible social risks and consequences. The Minister of Agriculture and Public Health were both dismissed by the Belgian government (Buzby and Chandran, 2003; Lok and Powel, 2000). Moreover, permanent criteria differences between the European Commission (EC) and Belgian authorities regarding the food products included in the monitoring program and its implementation (Lok and Powel, 2000) reduced the international credibility of the Belgian government.

Consequently, although in September 1999 Belgian authorities declared that most of its products tested negative for PCBs (Lok and Powel, 2000), countries which traded these products kept import bans for some time (Buzby and Chandran, 2003). An example is the USA, which did not lift import restrictions until the first months of 2000 (Buzby and Chandran, 2003).

Regarding the impact on the economy, although the cost of the crisis was small compared with the GDP of Belgium (Buzby and Chandran, 2003), it had a great impact on its agricultural and food industry sectors (Lok and Powel, 2000). Belgian authorities accounted the cost of the crisis to be $1.54 billion (€1.45 billion) divided in 50 percent of the total for each sector (Lok and Powel, 2000). Information regarding specific impacts on Belgian exports and agricultural production based on the available literature is detailed as follows.

Impact on exports

After the public announcement of the Belgian government regarding the dioxin crisis, more than 30 countries applied import bans on Belgian products. As explained previously, these bans were lifted in some cases much after than the announcement of the Belgian government claiming the end of the crisis. Although contamination was detected mainly in agricultural products, even Belgium chocolates were included in the list of suspected products in some countries (Buzby and Chandran, 2003). Therefore, the Belgian exports, both in the short and the long term, were also affected in non-agricultural products because of the damages in reputation and business relationships. According to Buzby and Chandra (2003), the positive rates of growth of beef meat products, swine products, dairy products, eggs and poultry products from 1989 to 1999, changed dramatically to negative rates of growth during the year 1998-1999 for the latter products except poultry. The most affected items were meat and swine products with negative rates of 32.1 and 14.2 percent, respectively. These were followed by eggs and dairy products with -6 and -3.7 percent, respectively.

Impact on production

According to the 1999 report of the National Institute of Statistics of Belgium (NIS), the agricultural subsectors most affected by the crisis at production level were poultry meat, meat (pork and beef) and meat products as well as cattle slaughter (Buzby and Chandra, 2003). Based on the comparison of agricultural monthly production indices of June 1999 versus June 1998, poultry meat products were the most affected, showing a negative change of 53.5 percent (Buzby and Chandra, 2003). Similarly, meat and meat products as well as cattle slaughter, show also a negative change of 42.4 and 29.5 percent in the same index, respectively (Buzby and Chandra, 2003). Although dairy products production was also affected by the crisis, the percentile reduction in this index (8.7 percent) was below the cattle slaughter category (Buzby and Chandra, 2003). At the same time this category shows a quicker recovery towards regular monthly decreasing changes as compared to the other mentioned categories (Buzby and Chandra, 2003).

2.5.4 Dioxin incidents in The Netherlands: The case of kaolinic clay contamination in 2004.

Because of previous food dioxin incidents and crises with catastrophic consequences for some European countries, diverse surveillance monitoring programs were implemented in The Netherlands in order to control the levels of contaminants in feed and food. With these programs, elevated levels of dioxins (PCDD) were identified in milk samples obtained from two dairy farms in 2004 (Hoogenboom et al., 2009).

The cause of these high dioxin levels was the use of contaminated potato peels as feed material. High levels of dioxins were found in kaolinic (marl) clay used for washing and sorting potatoes in the French fry production process and this was believed to be the main source of contamination (Hoogenboom et al., 2009; Kreft, 2006). Potato peels containing particles of clay (Kreft, 2006) were obtained from scrubbing processes carried out after sorting potatoes (Hoogenboom et al., 2009). Additionally, as potato peels were used as feed material not only for dairy cows but also for pigs, dioxins were found in pig fat samples, but were not as high as in milk samples. These lower levels are a result of the cooking treatment given to the peels before feeding the pigs (Hoogenboom et al., 2009). A chronological description of the contamination is depicted in Figure 2, which is an adaptation of previous research carried out by Kreft in 2006.

Increased levels of dioxins and dioxin-like PCBs were found in marine sediments from Queensland, Australia (Muller et al., 1999) and in "ball clay" used as feed additive coming from a mine located in the USA (Hayward et al., 1999; FDA, 1997). Similarly, elevated levels of dioxins were identified in kaolinic clay also used as feed component in Switzerland (Schmid et al., 2002). At that time, the possibility of contamination with dioxins from these materials was unknown. However, after acknowledgement, the use of these materials as feed additives or ingredients was forbidden (Hoogenboom et al., 2009).

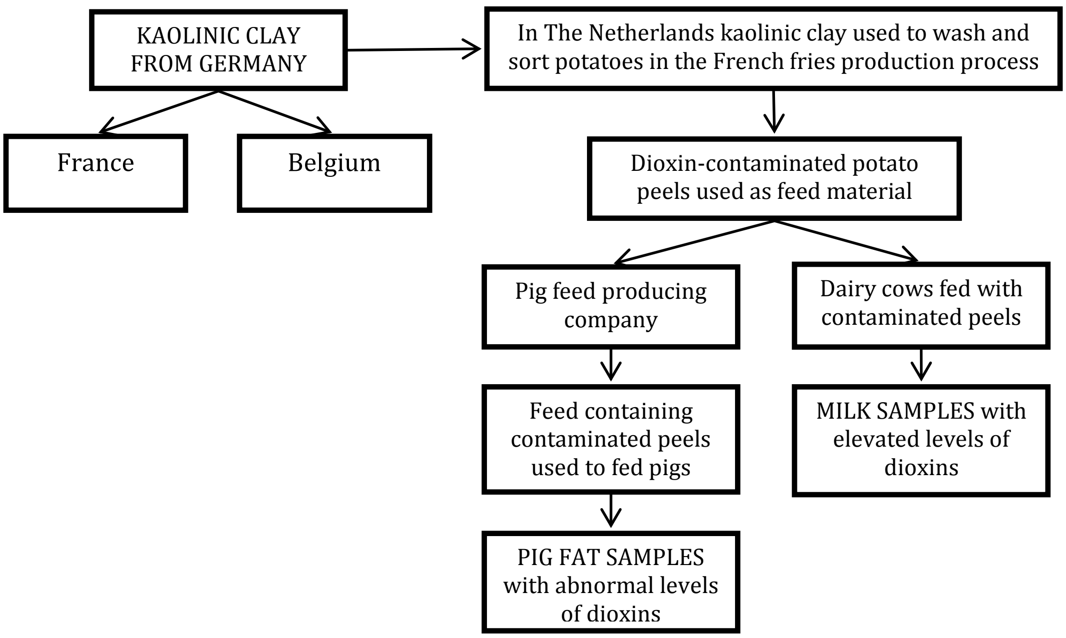

Figure 2. Chronological description of the kaolinic clay dioxin-contamination incident in The Netherlands in 2004 (Adapted from Kreft, 2006).

2.5.4.1 Problem dimension

Given the source of the contamination, not only milk and pig fat showed an increased level of dioxins, but also other potato-by products such as steamed peelings used for the potato pulp production, grey starch, and starch used to cover silage (Hoogenboom et al., 2009). Additionally, kaolinic clay imported from Germany to Belgium had also negative consequences in the feed supply chain of both countries (Kreft, 2006). Several animal farms were temporally closed in Germany and Belgium because of the use of contaminated feed (Kreft, 2006).

In The Netherlands, the consequences of the dioxin contamination were not different than in the other mentioned countries. Although at the end of the investigation only 2 dairy farms were temporally closed, during the investigation, different control measures were taken with the aim of reducing possible contamination on further stages of the food chain. Some of the measures were: 1) the separate storage of milk proceeding from 50 farms suspected to be contaminated, 2) the blocking of 3 potato processing companies and 2 intermediary storage units, and 3) the prohibition of animal movements for 162 pig and cattle farms (LNV, 2004).

As the starting point of the milk contamination was approximately 3 months before the identification of dioxins in milk, it is argued that milk with very low levels of dioxins reached the retail stage of the food chain. However, because of dilution effects, the Dutch Food Safety Authority (VWA) certified that these levels were not a risk for human health (Kreft, 2006)

Although the levels of dioxins in milk from dairy cows fed with contaminated potato peels decreased 2 months after changing the feed (Hoogenboom et al., 2009), the financial impact on the farm's economies was an important one. This is because during that period, dairy farms did not have any income for their milk production and had to pay for the destruction and analysis of the contaminated milk.

Although this dioxin incident did not become a serious threat for human health, it had important financial consequences for different stakeholders at different stages of the agri-food chain. At the same time, the importance of the monitoring programs was acknowledged as they permit the identification of increased levels of dioxins in milk and the early application of control measures in order to avoid as much as possible their possible negative impact.

CHAPTER 3: MATERIALS AND METHODS

This chapter includes the materials and methods used to develop this research. First, the explanation of the data used to build up the model including the structure of the Dutch dairy chain, the control measures applied during a dioxin contamination and the framework used for the economical analysis are depicted. This is followed by a description of the source of the information concerning the inputs of the model and the explanation of the sensitivity analysis and different scenarios including the inputs and outputs of the model.

3.1 Model building

3.1.1 Chain modeled: Dutch dairy chain

The Dutch dairy chain consists of five main stages: feed supplier, farmer, processor, retailer (exporter) and consumer. The Milk Dioxin Contamination Impact Model (MDCIM) takes into consideration the four first stages of the chain in order to analyze the economical impact of a dioxin contamination on the entire chain (as is considered for this model) as well as in each of the chain stages. In this project, the milk dioxin contamination of the Dutch dioxin incident in 2004 is used as a base line in order to analyze the sequence of events and the control measures taken by the Dutch food safety authorities in each of the chain stages. However, different from the dioxin incident of 2004 in which the source of the milk contamination was a potato processor (as first chain stage), in the MDCIM, the role of the source of contamination is played by a feed supplier of compound feed. The Dutch dairy chain and the sequence of events in the milk dioxin contamination of 2004 are depicted in Figure 2 and follows.

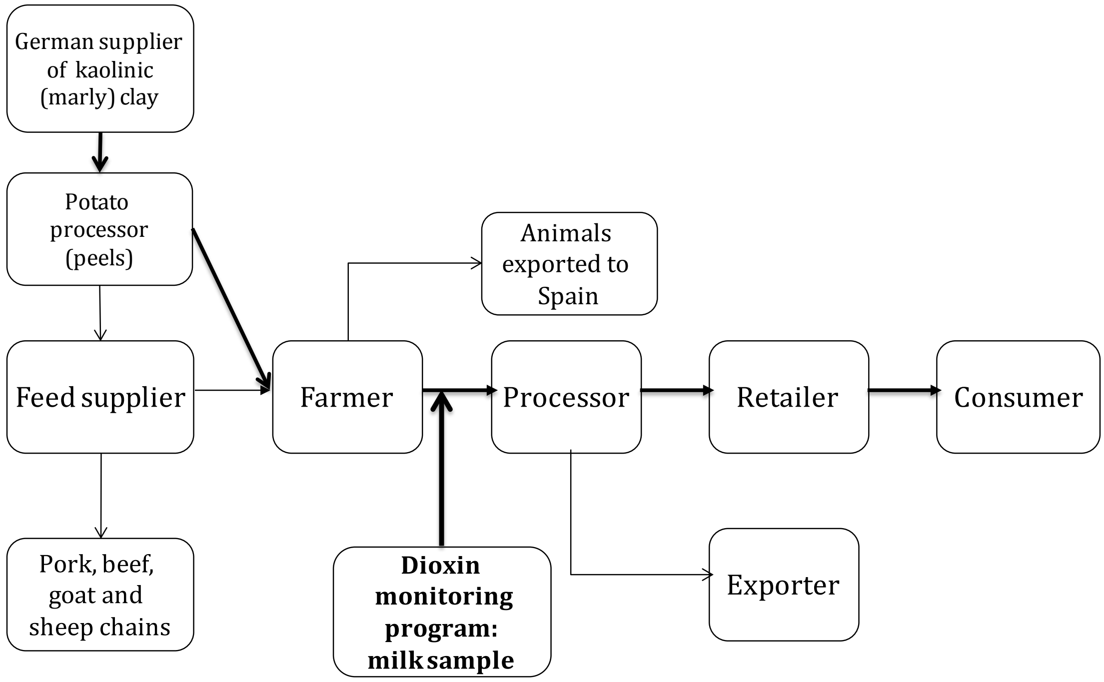

Figure 3. The Dutch dairy chain and the sequence of events of the milk dioxin contamination in The Netherlands in 2004 is shown with the bold arrows

3.1.2 Control measures included in the MDCIM

The model is based on the information available regarding the control measures applied during the dioxin incident which occurred in The Netherlands in 2004 (described in chapter 2) and the current Dutch legislation concerning animal food security. This legislation is part of the Policy Schedule Book of Animal Food Security (Beleidsdraaiboek diervoederveiligheid) version 01.a, published by the Ministry of Agriculture, Nature and Food Quality (LNV) in 2007. For the aim of this model, the control measures applied during a food crisis are divided in 4 groups of activities: (1) diagnostic activities, (2) blocking activities, (3) Recall activities and (4) destruction activities.

1. *Diagnostic activities*

Diagnostic activities include four kinds of sub-activities which are carried out in all stages of the food chain and consider all feed and food businesses involved in the agri-food chain which could be affected by the contamination. It is noteworthy to point out that feed and food businesses in this report are that defined in Reg (EC) 178/2002 (General Food Law). The four sub-activities are:

1.1. Risk analysis: It is carried out for each incident or crisis and for the entire agri-food chain with the aim of assessing the possible impact scenarios and the application of subsequent control measures.

1.2. Tracking and Tracing: This activity is carried out for each of the feed and food businesses involved in the incident with the aim of revealing the source of the contamination and its route of access to the food chain.

1.3. Monitoring and Sampling: This activity is carried out before and after the application of control measures with the aim of determining the presence or absence of dioxins in the products. It is done in order to identify contaminated products and to release the products when the dioxin levels comply with current regulations.

1.4. Identification and Registration of a dioxin contaminated product: This activity is carried out in all stages and all feed/food businesses involved in the incident in order to identify and register the contaminated products which afterwards will be sent to destruction.

2. Blocking activities

Blocking activities are carried out based on the "Precautionary Principle" of Reg. (EC) 178/2002 regarding a suspicious of contamination in a feed or food businesses with the aim of preventing the contamination in further stages of the chain. These activities are also applied in specific feed and food businesses when the contamination is verified in order to isolate and control the contamination. For the aim of this model, in this group of activities, only one sub-activity is considered: movement standstill.

This sub-activity includes the prohibition of trading or moving any suspected or verified contaminated livestock and/or feed and food products. This sub-activity is applied on the first three stages of the agri-food chain such as: feed supplier, dairy farmer and milk processor.

3. Recall activities

When it is suspected and/or verified that unsafe contaminated products have reached the consumer´s stage or further stages from their origin, recall activities are carried out to withdraw the product from the market and downstream businesses (Velthuis et al., 2009). For the aim of this model, these activities are carried out by the feed supplier, the milk processor and the retailer. Recall activities are divided in 5 sub-activities:

3.1. Recalling feed and food products: This sub-activity is carried out by the feed supplier, milk processor and retailer with the aim of withdrawing from the market and/or previous stages suspected and/or contaminated feed and milk.

3.2. Replacing contaminated feed: In the MDCIM model, replacing contaminated feed is carried out by the feed supplier who withdraws contaminated feed from the dairy farmer and replaces it with non-contaminated feed.

3.3. Recall announcement: In the MDCIM model, this sub-activity is carried out by the feed supplier and the milk processor who should make a public announcement and/or an announcement on their website, regarding the recall of their feed and/or food contaminated products.

3.4. Refunding consumers: In the MDCIM model, this sub-activity is carried out by the milk processor which should refund the consumers (final stage of the chain) for the recalled products already sold to them.

3.5. Consumer help desk: In the MDCIM model, the milk processor and the retailer carry out this activity. It involves activities aimed to guide and assist consumers with the procedures of refunding, disposal and possible health consequences of the recalled products.

4. <u>Destruction activities</u>

In this category, all sub-activities carried out by the first three stages of the chain and which have the aim of destroying all contaminated and recalled feed/food products and contaminated livestock are included.

4.1. Skimming of raw milk: Given the fact that higher levels of dioxins are concentrated in the cream of the milk as compared to its other components, the milk is required to be skimmed before the destruction procedure. This is in order to apply different destruction procedures to each of the obtained components. This sub-activity should be carried out by the dairy farmer and the milk processor.

4.2. Destruction of contaminated products (feed and milk) and livestock: Although all the contaminated products and livestock are destroyed by incineration, different destruction procedures are applied for feed and food products and for livestock. In this regard, this sub-activity is divided in two categories: 1) destruction of contaminated products and 2) destruction of livestock.

4.2.1. Destruction of contaminated products: The destruction of contaminated products is carried out in two different processes: 1) incineration of low risk material and 2) incineration of high risk materials. Contaminated feed and low fat raw milk are destroyed as low risk material while consumption milk and raw cream are destroyed as high risk material.

4.2.2. Destruction of contaminated livestock: It is noteworthy to remark that this activity in the case of a dioxin milk contamination is not compulsory by governmental authorities. Therefore, their implementation of it is based on the criteria of the farmer (owner) of the livestock. This sub-activity is divided in three steps: 1) sacrifice, 2) slaughter and 3) incineration. In the MDCIM model, the sacrifice of animals is made by a veterinary in each of the farms. Afterwards, animals are picked up by a company (RENDAC B.V.) which carries out the process of slaughter and incineration.

4.3. Replacing livestock: This sub-activity is carried out in the second stage of the chain. It involves the replacement of the livestock destroyed in the previous sub-activity.

In Table 3, a summary of the activities and sub-activities taken into consideration in the model is depicted. It regards the activities which concern the whole agri-food chain and those which only concern specific stages of the chain.

Table 3. Summary of control measures divided by activities and sub-activities (considered in MDCIM) for each member of the chain and for the entire agri-food chain.

Chain Member	Activities and Sub-activities			
	Diagnostic	Blocking	Recall	Destruction
Feed supplier	1. Tracking and Tracing 2. Monitoring/sampling 3. Identifying/registering contaminated products	1. Movement standstill of feed	1. Recall feed 2. Replace feed 3. Recall announcement	1. Destroying contaminated feed
Dairy Farmer	1. Tracking and Tracing 2. Monitoring/sampling 3. Identifying/registering contaminated products	1. Movement standstill of livestock and milk		1. Skimming raw milk 2. Destroying raw milk and cream 3. Destroying animals 4. Replacing animals
Milk Processor	1. Tracking and Tracing 2. Monitoring/sampling 3. Identifying/registering contaminated products	1. Movement standstill of milk	1. Recall milk 2. Recall announcement 3. Consumer helping desk	1. Destroying consumption milk 2. Skimming raw milk 3. Destroying raw milk and cream

			4. Refunding consumers	
Retailer	1. Tracking and Tracing 2. Monitoring/sampling 3. Identifying/registering contaminated products		1. Recall milk 2. Consumer helping desk	
Entire Agri-food Chain	1. Tracking and Tracing 2. Monitoring/sampling 3. Identifying/registering contaminated products 4. Risk Analysis	1. Movement standstill - feed 2. Movement standstill- livestock 3. Movement standstill- milk	1. Recalling feed and milk 2. Replacing feed 3. Recall announcement 4. Refunding consumers 5. Consumer help desk	1. Skimming raw milk 2. Destroying contaminated products/livestock 3. Replacing livestock

3.1.3 Partial budgeting

The calculation of the economical impact of a dioxin incident in the MDCIM model is based on a partial budgeting approach. It is the comparison between a basic scenario without the incident and a second scenario with the incidence. It is related to the calculation of the negative effects of the dioxin incident (extra costs and returns forgone) and it´s positive effects (additional returns and reduced costs). The net result is the subtraction of the sum of the positive economical effects minus the negative ones in order to find the net economical impact per stage of the chain and for the entire one (Velthuis et al., 2009).

3.2 Inputs of the model

The information used as input of the MDCIM model has been obtained based on relevant literature regarding the Dutch dioxin incident of 2004 (included in chapter 2), expert knowledge (obtained by interviews) from Ine van der Fels (expert on modeling food safety hazards in agro food chains) and Ron Hoogenboom (expert on contaminants in animal feed) from RIKILT- Institute of Food Safety of Wageningen UR, Annet Velthuis (expert of food safety economics) from the Business Economics Group of Wageningen UR and Jan Wijma (expert on feed business) from LNB. Additional information required by the MDCIM model as input which was not available from the previous sources, has been based on assumptions. A detailed explanation of each input and its source is included in the table of inputs (Table A of the model) in the Appendix of this document

3.3 Sensitivity analysis

The sensitivity analysis carried out to analyze the effect of the selected inputs on the total economical impact obtained by the MDCIM model is based on a univariate analysis. This is done by the increase and the reduction of 10% of each input value and the recording of the change in the total impact value calculated in percentage. This analysis is carried out considering two scenarios: the first considers only one member of each stage of the chain and the second considers different number of members of each stage at the third day of the beginning of the contamination.

3.4 Scenario analysis

The scenario analysis is carried out with the aim of measuring the relative change of the total economic impact with respect to the entire food chain, to each stage of the chain and to each group of activities carried out within each stage. There are two scenarios (0, 1) and each has the following composition:

- Scenario 0:

This scenario is the base line of the calculation. In this scenario the MDCIM model includes only one feed or food business in each stage of the chain. In this regard, it shows the initial distribution of the total impact for each stage of the chain and each group of activities.

- Scenario 1:

This scenario pictures the feed and food business contaminated at the third day after the beginning of the contamination/incident. The number of feed and food contaminated businesses depends on the frequency of delivery of feed and milk along each stage of the chain. In this regard, this scenario is composed of 1 contaminated feed supplier site which until the third day of contamination delivers contaminated feed to 75 dairy farms. These 75 contaminated dairy farms deliver raw milk to 3 milk processor sites which until the third day have delivered consumption milk to 189 retailers.

CHAPTER 4: RESULTS

In this chapter a detailed explanation of the main findings resulting of this research are depicted. This includes: 1) a description of the developed model as well as of the economical analysis performed in this study, 2) the outcomes of the model regarding the economical impact of the dioxin crisis for the entire dairy chain as well as for each of its chain stages, and 3) the results of the sensitivity and scenario analysis based on the inputs used in the model and the outputs given by the model, respectively.

4.1 Model description

The MDCIM is a deterministic simulation model created in Microsoft Excel 2003. The aim of the model is to quantify the economical impact of a dioxin incident in the Dutch dairy chain specifically on consumption milk. The model simulates the route of a dioxin contamination of the milk as a result of the contamination of the animal feed. In this sense, the contamination begins in the first stage of the milk food chain (feed supplier); for example, due to the use of dioxin-contaminated raw material as ingredient of the compound feed. The contaminated feed is later used in the second stage of the milk food chain (dairy farm) resulting in the contamination of the dairy cows. Milk produced by these cows, afterwards, reaches the third stage of the chain (milk processor) where milk is processed in different dairy products including consumption milk. The processed milk is then distributed in the fifth stage of the chain (retailer) in order to be commercialized and further consumed by the final stage of the chain (milk consumer).

Although the model was based on a specific dioxin incident, it pursues to be used to predict the impact of any dioxin contamination inside of the Dutch dairy chain specifically in consumption milk. Consequently, the model includes the quantification of other activities mentioned in the Dutch legislation that might or might not be applied during the occurrence of a dioxin contamination.

The model consists of 3 tables: 1) A: “Input” 2) B: “Calculations” and 3) C: “Impact dimension”. The first table (A) includes all the inputs used in formulas to calculate the economical impact of a dioxin incident/crisis. The formulas and their results are included in the second table (B) in which the economical impact for the entire dairy chain as well as for a single member (farm/firm) in each chain stages are obtained. The third table (C) summarizes the economical impact captured in table B. It includes the damage dimensions varying the number of feed and food business of each stage of the chain involved in the incident and the number of days from the starting point of the incident.

4.1.1 Table A: Inputs

The inputs used in the model are divided into the following variables: Costs (labor, external services and transport), Product values (feed, milk, cows and calves), Stage specific activities labor hours (tracking and tracing, sampling, etc), Stage specific number of samples and number of batches-samples sent to laboratory, Stage specific variables (i.e. number of kilograms of feed recall at feed supplier stage) Stage specific blocking time period (i.e. number of days farm is blocked).

4.1.2 Table B: Calculations

Table B describes all possible control measures that might or might not be applied during the occurrence of a dioxin contamination of compound feed and milk in the dairy food chain. The control measures are applied throughout all the stages of the chain, in specific members of each stage, depending on their participation in the contamination.

The effects of the application of each control measure are economically assessed using a Partial Budgeting approach. This is with the aim of determine negative (extra cost and returns forgone) and/or positive effects (additional returns and reduce costs) of its application in each stage specific companies involved in the dioxin contamination. Negative and/or positive effects are identified by the comparison of the occurrence of these effects in a basic scenario without contamination.

4.1.3 Table C: Impact dimension

This table (C) summarizes the economical impact of a dioxin incident for the total food chain as well as for a single feed/food business of each stage of the chain. Additionally this table allows to modeling the possible impact of a dioxin incident varying the number of feed and food business and the time between the starting point of a contamination and its identification.

4.2 Economical analysis of the study

It is worthy to remark that although the MDCIM is economically analyzed based on a partial budgeting approach, it does not include any positive effect (extra returns and reduce costs) on any stages of the agri-food chain as a result of a dioxin incident. This is because the application of the control measures with the aim of managing the incident does not have any positive economical effect in any of the stages of the agri-food chain considered in this model.

4.2.1 Calculation of the negative economical impact of a dioxin incident

In the following paragraphs, it is explained the calculations carried out to account the negative impact (extra costs and returns forgone) of a dioxin incident derived of the application of the control measures (group of activities). Specific calculations of each table of the model are detailed in the Appendix.

4.2.1.1 Summary of inputs used in the calculation of extra costs

The inputs used to calculate the extra costs are summarized in Table 7, divided per group of activity, sub-activity and extra costs items

Table 4. Extra cost items and the inputs considered in the calculation of extra costs divided by group of activity and sub-activities.

Group of activity	**Sub-activities**	**Extra cost items**	**Inputs considered in calculation**
Diagnostic activities	- Risk Analysis - Tracking and Tracing - Monitoring and Sampling - Identification and Registration of contaminated products	Extra labor	- External service tariff labor HS (Risk Analysis and Track &Tracing) - External service tariff labor MS (Monitoring/Sampling and Identification/ Registration) - Labor hours for each specific activity in each stage
Diagnostic activities	- Monitoring and - Sampling	Transport costs	- Number of batch of samples - Transport cost per batch of samples
Diagnostic activities	- Monitoring and Sampling	Tests costs	- Test cost per type of test (screening or confirmation) - Type of sample (feed or milk) in each stage of the chain
Blocking activities	- Movement standstill – feed - Movement stand still –milk - Movement stand still – - livestock	Rental costs for feed, milk and livestock	- Cost price of the products at the storage place (milk and feed) - Cow for slaughter sale price / Calf for industry sale price - Amount of product stored (feed in normal, separate and centralized storage; and milk) - Amount of animals not sold for slaughter and calves not sold to industry - Block time for feed (different storage types), milk and livestock - Interest rate

Blocking activities	- Movement standstill–feed - Movement standstill–milk	Extra facility for storage	- Block time for feed (different storage types) and milk. - Facility storage renting cost for feed and milk.
Blocking activities	- Movement standstill–feed	Extra labor	- External services tariff LS - Labor hours for each specific activity in each stage
Blocking activities	- Movement standstill–feed	Transport costs	- Transport cost - Amount of feed stored (separate and centralized storage)
Blocking activities	- Movement standstill-milk	Extra energy	- Cooling milk energy cost - Amount of milk stored - Block time
Blocking activities	- Movement standstill-livestock	Extra feed	- Block time - Amount of animals not sold for slaughter and calves not sold for industry - Adult & calf feed intake - Feed dairy cow & feed calf sale price
Recall activities	- Recall of products - Replacing feed	Transport costs	- Transport cost per product recalled or delivered - Amount of product recalled/delivered
Recall activities	- Recall of products - Consumer help desk - Replacing feed	Extra labor	- Own employees tariff MS (Consumer help desk) and LS - Labor hours used to recall products(milk and feed) and replace products (feed)
Recall activities	- Replacing feed	Feed replace cost	- Amount of feed replace - Feed cost price
Recall activities	- Refunding consumers	Refunding consumers	- Post mail stamps - Consumption milk sale price - Consumption milk sold from retailer - Percentage of milk refund to consumers
Recall activities	- Recall announcement	Recall announc.	- Newspaper publishing - Design costs (feed supplier) - Press release - Number of recall announcements
Destruction activities	- Destruction of contaminated products	Destruction costs	- Low or high risk material destruction cost - Amount of product produce, recalled and storage - Block time (dairy farm)
Destruction activities	- Destruction of contaminated products - Skimming of raw milk	Transport costs	- Transport cost per product - Amount of product recalled and storage - Block time (dairy farm)
Destruction activities	- Skimming raw milk	Skimming costs	- Skim costs - Amount of raw milk for skimming - Blocking time (dairy farm)

Destruction activities	- Destruction of livestock	Labor costs	- Professional services of veterinary and expenses costs - Number of visits of veterinary - Time required to sacrifice per animal - Number of animals to sacrifice
Destruction activities	- Destruction of livestock	Sacrifice material costs	- Sacrifice material cost per animal - Number of animals to sacrifice
Destruction activities	- Destruction of livestock	Slaughter and incineration of animals	- Slaughter and incineration - Number of animals to destroy
Destruction activities	- Destruction of livestock - Replacing livestock	Transport costs	- Number of visits of RENDAC (destruction of livestock) - Average weight of milking cow - Number of animal replaced - Transport cost RENDAC - Transport cost for replacing livestock
Destruction activities	- Replacing livestock	Replacing costs	- Number of animal replace - Milking cow –sale price

4.2.1.2 Summary of inputs used in the calculation of returns forgone

The inputs used to calculate the returns forgone are summarized in Table 8, divided by group of activity, sub-activity and returns forgone cost items

Table 5. Extra returns forgone cost items and the inputs considered in the calculation of returns forgone divided by group of activity and sub-activities

Group of activity	**Sub-activity**	**Returns forgone cost items**	**Inputs considered in calculation**
Blocking activities	- Movement standstill-livestock	Margin loss for calves bigger than 10 days	- Calf regular sale price - Calf >10 days sale price - Number of calves not sold to industry
Recall activities	- Recall of products	Milk sales loss	- Consumption milk sale price at retailer level - Consumption milk cost price at retailer level - Milk turnover per day - Milk not in stock
Recall activities	- Replacing feed	Margin loss for feed replaced	- Amount of feed replaced - Feed dairy cows sale price - Feed dairy cows cost price
Recall activities	- Recall of products	Milk sales loss	- Consumption milk sale price at retailer level - Consumption milk cost price at retailer level - Milk turnover per day - Milk not in stock

Destruction activities	- Destruction of contaminated products	Losses for products destroyed	- Contaminated products sale price (feed at supplier level, raw milk at farmer level and consumption milk at processor level) - Amount of products produce, recalled and stored - Block time (dairy farm)
Destruction activities	- Destruction of livestock	Losses for animal destruction	- Number of animals destroyed (cows and calves) - Milk cow average weight - Cows for slaughter and calves for industry sale price

4.2.1.3 Assumptions

The economical impact obtained in this model is based on the following assumptions:

Diagnostic activities

- At retailer stage level, it is assumed that any kind of activities regarding monitoring & sampling, and identification & registration of contaminated products took place.

Blocking activities

- At processor level, it is assumed that there is no extra storage facility is required to store milk.

Recall activities:

- It is assumed that all recalled products are destroyed. At the same time it is assumed that all products stored are contaminated and consequently destroyed.
- It is assumed that all feed recalled is replaced by the feed supplier.
- It is assumed that 50% of the milk withdrawn has already been sold by the retailer and its price must be refunded to consumers. It is assumed that each consumer has bought an average of 2 kg of milk.

Destruction activities

- At feed supplier, dairy farm and milk processor, it is assumed that the transport costs are included in the destruction costs of the contaminated products for each type of destruction material.

- At dairy farm stage, it is assumed that no destruction activity regarding livestock is taking place. Therefore, the kind of activities and items related to destruction and replacing of livestock are not taken into account.

Number of feed and food businesses contaminated in each stage of the chain

- It is assumed that only one feed production business site is the source of the contamination. It is assumed that contaminated feed of this feed production business is distributed to 25 different farms per day, with a deliver cycle of 2 visits per month for the same farm. Contaminated milk is delivered each 3 days to the milk processor. It is assumed that each 25 contaminated dairy farms deliver milk to one different milk processor site. In this regard, 3 different milk processor sites are contaminated each three days. It is assumed that each milk processor site delivers milk to 63 retailers per day. In this regard, 189 retailers are contaminated each three days.

4.3 Economical impact for the entire food chain and for each chain stage

The total economical impact for the entire dairy chain is accounted to be € 3´022.713 of extra costs and returns forgone obtained in Scenario 0 (SC0) in which one single feed or food business in each stage of the chain is considered. The total economical impact value includes the extra cost of carrying out a Risk Analysis which is not included in the sensitivity and scenario analysis. This is because this is a single activity carried out for the entire food chain and for each incident. Therefore, it is not worthy to include this cost in the further analysis because it does not depend on each stage or feed/food business operators involve in the incident.

In the following analysis, the total economical impact in the entire chain is accounted on €3´019.713 (without Risk Analysis costs), which is divided in: 1) €1`716.742 (56,85%) per a feed supplier production site in the first stage of the chain, 2) €38.078 (1,26%) per a dairy farm in the second stage of the chain, 3) €1`260.375 (41,74%) per milk processor production site in the third stage of the chain and 4) €4.518 (0,15%) per retailer site (Figure 4).

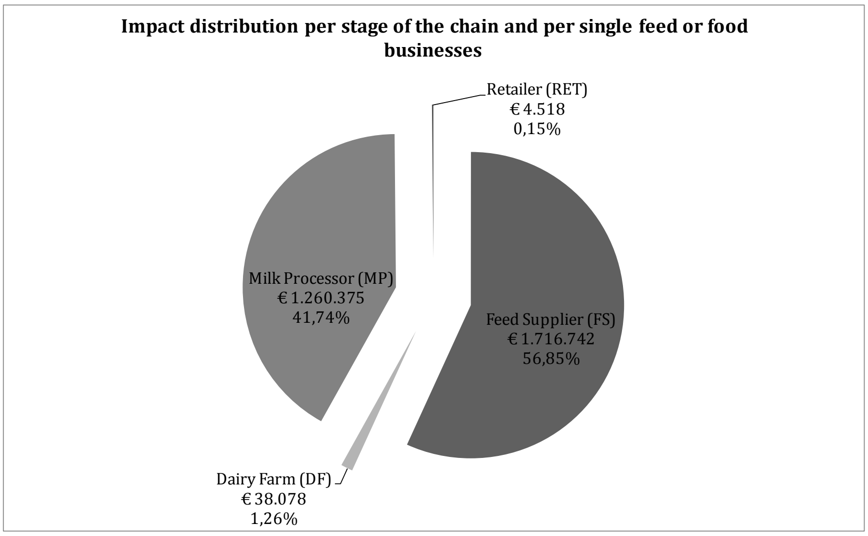

Figure 4. Impact distribution per stage of the chain and per single feed or food businesses

4.3.1 Economical impact per group of activities

From the total economical impact, the destruction activities are the most important cost contributors for the entire chain. They are accounted on €2´051.569 (67,94%) of the total economical impact. They are followed by the recall activities which are accounted on €811.011 (28,56%) of the total economical impact. Blocking activities (€49.473; 1,64%) and Diagnostic activities (€52.660; 1,74%) are the less important cost contributors for the total economical impact in the occurrence of a dioxin incident (Figure 5).

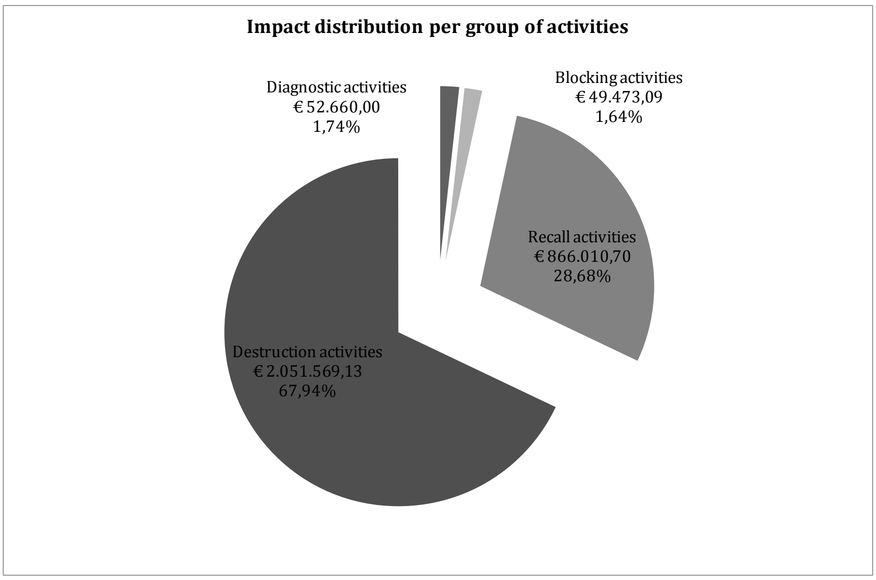

Figure 5. Impact distribution per group of activities

4.3.2 Economical impact per group of activities and stage of the chain

Diagnostic activities

The contribution of diagnostic activities for the total economical impact of a dioxin incident is concentrated in the feed supplier stage with more than 70% of the costs regarding diagnostic activities. In the second, third and fourth place are located farm (19,45%), processor (8,63%) and retailer (0,95%) stages respectively.

Blocking activities

The contribution of blocking activities for the total impact per stage of the chain is basically divided between the feed supplier stage with more than 50% of the costs and the processor stage with more that 45%. Less important is the contribution of the farmer stage with less than 2% of the contribution for the total impact.

Recall activities

The contribution of recall activities for the total impact per stage of the chain is salient for the feed supplier stage which contributes with 87,74% of the total costs related to this activities. It is followed by the processor and retailer with 11,8% and 0,46% of the total impact related to recall activities.

Destruction activities

The contribution of destruction activities for the total impact per stage of the chain is basically divided between the processor and feed supplier stages with 55,12% and 43,56% of the total costs respectively. In less extent, the contribution of farmer stage is important with less than 2% of the total costs.

The contribution of each group of activities per each stage of the chain is depicted in Figure 6

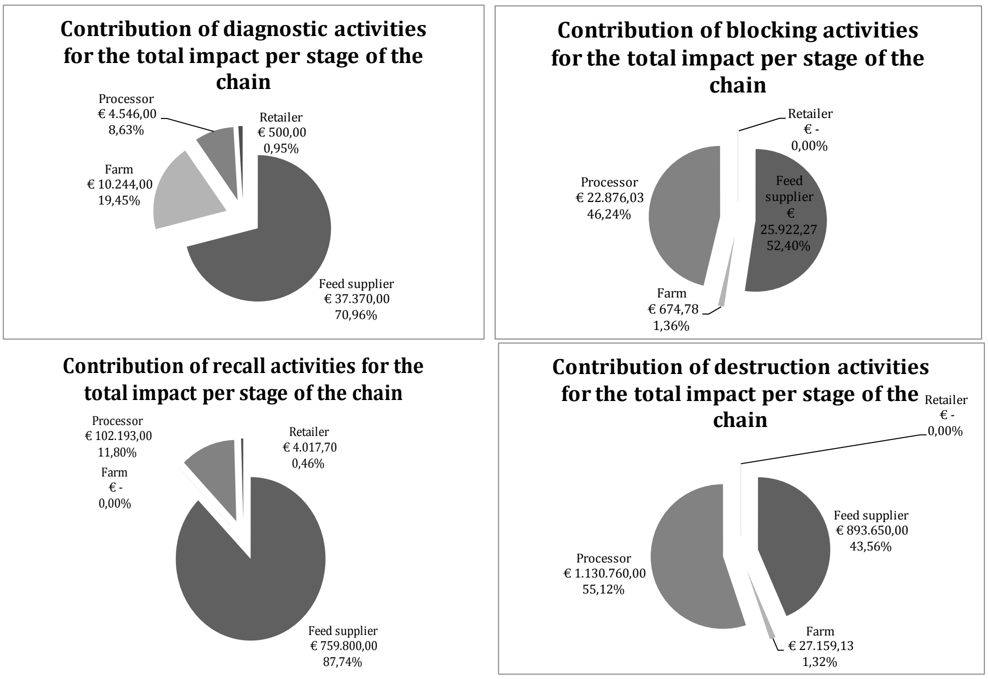

Figure 6. Contribution of each group of activities for the total impact per stage of the chain

4.4 Sensitivity analysis

Two sensitivity analyses were carried out in this study. The first (SC0) was made considering only one member (feed of food businesses) per stage of the chain, while in the second analysis (SC1), it was considered the number of feed and food businesses involved in a dioxin incident at the third day after the start point of contamination. These analyses were carried out with the aim of identifying the inputs which more affects the outputs of the model as the total economical impact obtained.

4.4.1. Sensitivity analysis SC0

In the results discussed in this chapter, it is only considered the inputs which affect in more or less than 1% the economical impact obtained by the model. Considering only one feed or food businesses per stage of the chain, the amount of feed and milk recalled as well as the sale prices of feed for dairy cows (at feed supplier stage) and of consumption milk at milk processor stage are the most important inputs obtained in the sensitivity analysis. Their importance is based on the fact that an increase or reduction of 10% in each of mentioned inputs could increase or reduce between 3% and 6% the result of the total impact obtained in the model.

At the same time an increase or reduction of 10% in the values of the inputs of destruction cost of high risk material, increase and reduce between 1% and 2% the total economical impact obtained in the model.

Although the percentile effect in absolute value for input of raw milk sale price is the same as for the input of destruction cost of high risk material, it effect on the total economical impact is different. In this sense an increased or reduction of 10% in the value of raw milk sale price at farmer stage, could reduce or increase the value of the total economical impact in between 1% and 2%.
Part of the results of the sensitivity analysis of SC0 is depicted in Figure 7.

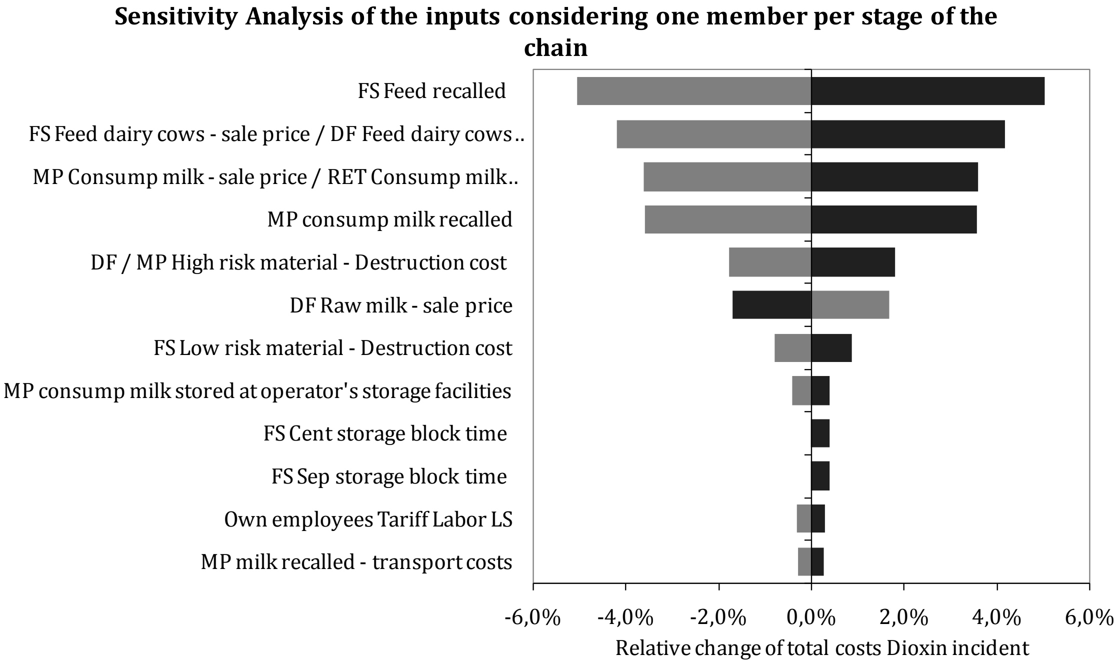

Figure 7. Sensitivity analysis of the inputs considering one member per stage of the chain

4.4.2. Sensitivity analysis SC1

From the results of the sensitivity analysis SC1, only the inputs which could affect in more or less than 1% are discussed in this chapter, which are depicted in Figure 8.

Given 1 feed business (site) at feed supplier level, 75 dairy farms at farm level, 3 processor business (sites) at processor level and 189 retailers (sites) at retailer level, the results of the sensitivity analysis show that: 1) an increase or reduction of 10% in the sales prices of consumption milk and the amount of consumption milk recalled at the milk processor level, could increase or reduce the total impact in more than 3%.

Different than the result obtained in the sensitivity analysis at SC0, the amount of milk produce and the blocking time at farmer level show a high influence of more than 2% but less than 3% on the total impact.

Although the effect on the total impact of the destruction cost of high risk material, the amount of feed recalled and the sale price of feed for dairy cows is lower than in the SC0, they are still above 1% of the total impact.
It is worthy to remark that although raw milk sale price at farmer level shows a lower effect on the total impact value (<1%), it keeps the same opposite effect than in the SC0.

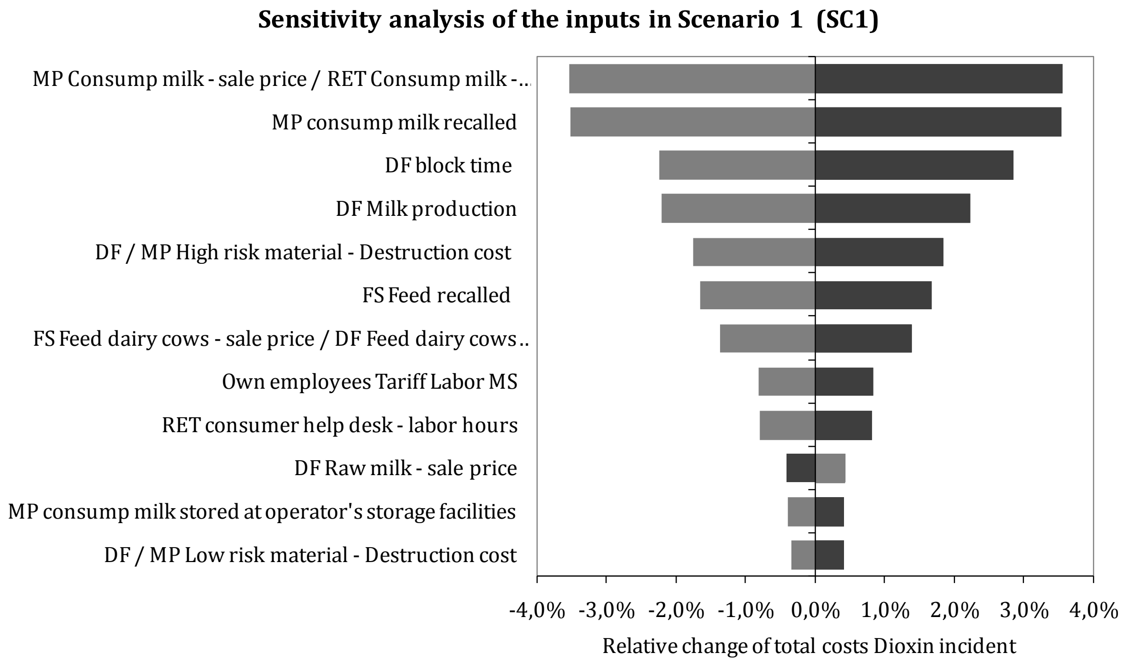

Figure 8. Sensitivity analysis of the inputs in Scenario 1 (SC1)

4.5 Scenario Analysis

4.5.1. Distribution of total economical impact per stage of the chain

SC0 and SC1 are different concerning the number of feed or food business which is involved on a dioxin incident at the third day after the start point of the contamination. In this regard the results obtained in the comparison between SC0 and SC1 show that the contribution for the total economical impact in the feed supplier stage is reduced in SC1 with respect to SC0 (from 56,85% to 18,64). At the same time it is shown an increase in the contribution of the farmer stage (from 1,26% to 31,02%) and the retailer stage (from 0,15% to 9,27%). The contribution of the processor stage is still in around 40% (Figure 9).

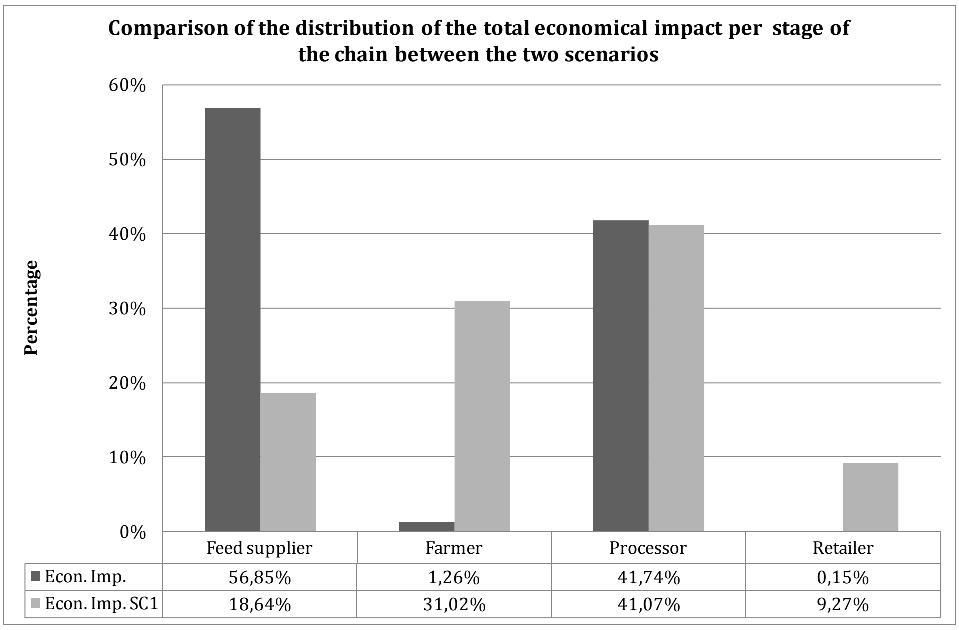

Figure 9. Comparison of the distribution of the total economical impact per stage of the chain between two scenarios.

4.5.2. Distribution of the total economical impact per group of activities (control measures)

At the third day after beginning the contamination, the contribution of each group of activity (control measure) remains in almost the same proportions. It is important to remark the increase of the contribution of diagnostic activities from 1,74% to 9,92% to the total economical impact obtained in the SC1. At the same time, there is a reduction of the contribution of recall activities (from 28,68% to 19,83%) in the SC1. However, the proportion on the level of contribution of each activity is still concentrated in recall and destruction activities (Figure 10).

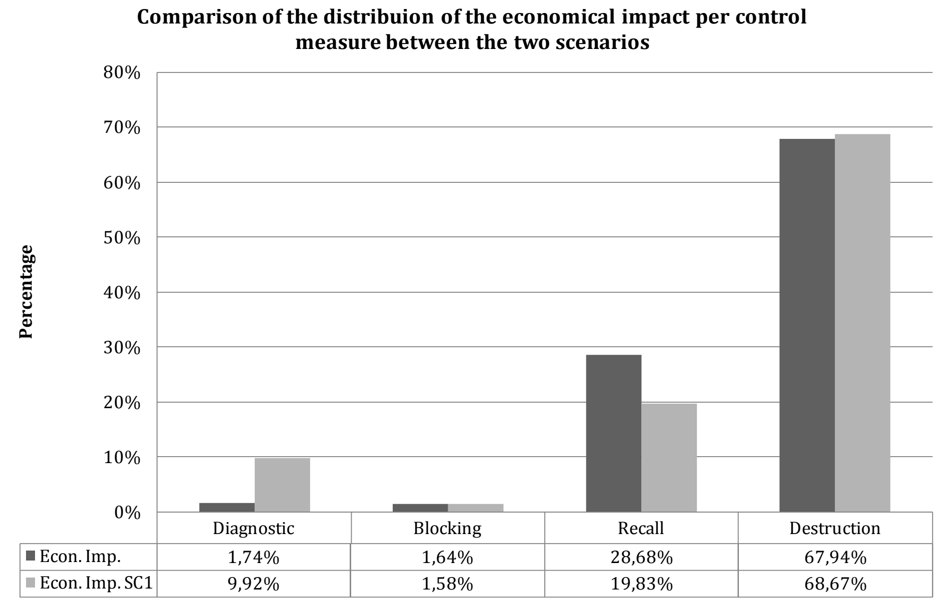

Figure 10. Comparison of the distribution of economical impact per control measure between two scenarios

Although the main contributors to the total economical impact in SC0 are the feed supplier and milk processor stages, after the third day of contamination, it is shown that the contribution of the feed supplier is going to reduced along the time (from 64,33% to 5,11), while the contribution of the milk processor remain almost in the same percentage (around 45%). At the same time, the contribution of farmer after the same day is located between 35 and 40% while, the contribution of the retailer remain stable at the same proportion (10%) (Figure 11).

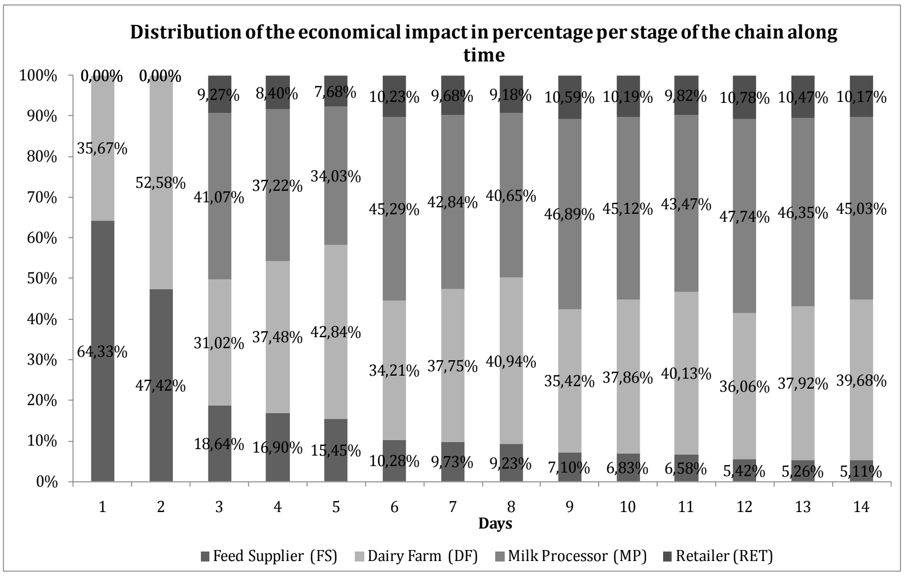

Figure 11. Change in the distribution of the economical impact per stage of the chain along time

Chapter 5: Conclusions and Discussion

In this chapter, the main conclusions which have been derived from the results (Chapter 4) and the objectives (Chapter 1) of the study are presented. A discussion with respect to the conclusions and methodology (Chapter 3) used to make the research follows. Finally, suggestions of topics for further research are proposed.

5.1 Conclusions

The objective of this research is to estimate the financial consequences of a dioxin incident over the agri-food businesses more specifically members of the Dutch dairy chain.

The main conclusions of this study are:

1) The total economical impact of a dioxin incident strongly relates to the proportion of feed and food businesses involved.

The total economical impact of a dioxin incident for the whole Dutch dairy chain when taking into account only one business in each stage of the chain, has been estimated to be €3´022.713. However, this value is not absolute and varies depending on the number of feed and food businesses which are involved in a dioxin incident in each stage of the chain. As an example, based on the results obtained by the model, at the third day after the beginning of the contamination, when considering 1 feed supplier, 75 dairy farms, 3 milk processors and 189 retailers, the total impact value could be as high as €9’210.056. Therefore, although the impact value obtained for each stage of the chain could be correct, it is very important to consider the effect the number and proportion of business involved in each stage of the chain in order to achieve a more precise total impact value.

2) The milk processor followed by the dairy farmer contributes the most to the total economical impact of the contamination.

Initially, when considering only one business per stage of the chain, feed supplier and milk processor together, contribute with more than 97% (56.85% and 41.74%

respectively) of the costs to the total impact. However later on, when considering the probable number of affected business in each stage of the chain, the milk processor followed by the dairy farmer, in almost equal percentage (around 40%), are the two stages of the chain which contribute most to the total impact. Consequently, although the total impact is concentrated in highest percentage at the feed supplier and processor level, the value of this impact when taking into account the number of feed and food businesses involved in a dioxin incident in each stage of the chain could change the distribution on the impact along the chain. In other words, although the contribution of impact of one farm at farmer level is only 1.26% of the total impact value, the high number of farmers involved could increase this percentage and reach more than 35% as seen in the results of the study. This goes in line with the results obtained by Buzbi and Chandran (2003) who calculated and analyzed the economical impact of the dioxin crisis in Belgium of 1999. During the Belgium dioxin incident, the most affected stages of the chain were the processors and farmers, and to a less extent retailers and feed businesses. This was because the amount of feed contaminated when compared to the amount of feed produced and when compared to the number of contaminated farms and processors due to this initial feed contamination, was insignificant.

<u>3) The destruction activities and the recall activities are the most important contributors to the total impact value</u>

Based on the results of this study, independently of the number of feed and food businesses involved in each stage of the chain, destruction and recall activities are the most important contributors (> 70%) to the total impact value when the occurrence of a dioxin incident. This is supported with the results of the sensitivity analysis in which the number of kilograms of contaminated products (feed and milk) produced, recalled and destroyed as well as their sale prices and the destruction costs are salient inputs affecting the total impact value. Based on the analysis of each input separately, a variation of 10% up or down of the value of each them, could increase or decrease from 1% to 3.6% the total economical impact for the entire chain. As an example, an increase of 10% regarding the number of kilograms of milk recalled could increase in 3.5% the amount of the total economical impact.

It is noteworthy to mention that although the cost per sample of testing for dioxin presence is high, its influence on the impact value is far of being salient. This could suggest and enhance the importance of a monitoring surveillance program as a preventive measure with the aim of reducing the amount of products recalled that contribute in a large extent with the increase of the total impact value when the occurrence of a dioxin incident.

5.2 Discussion

Number and proportion of business for each stage and for the entire chain

Given the influence that the proportion of businesses of each stage has on the estimation of the total economical impact, it is highly important to obtain accurate information regarding the number of business affected during the occurrence of a dioxin incident. In this regard, it is important to verify the proportion of contaminated farms per feed supplier and of contaminated processors per farms and contaminated retailers per processor. Like this, a more precise amount of the total impact and more accurate proportions of this impact for each stage of the chain and for the entire chain could be obtained.

Reliability of the model

The MDCIM is valid and reliable depending on the validity and reliability of the inputs used to fulfill it. Consequently, more precise information should be obtained in order to avoid assumptions, which in this research are frequent due to the gap of information related to the dioxin incidents. For this, more interviews with experts of different stages of the chain is needed in order to achieve who were involved in such an incidence and activities which are related to this type of incident should be conducted. Like this, the model could be improved and become more precise and link fully with a real situation.

Sensitivity analysis

Based on the univariate analysis used to assess the influence of each of the inputs on the total impact value, valuable results regarding the most important inputs and the extent of their influence were achieved in this research. However, this analysis does not take into account the possible interrelations between inputs which could affect in some extent the results obtained. Consequently a multivariate analysis could be applied in order to assess these interactions and improve the understanding about the effects of the inputs in the total impact value.

Although the sensitivity analysis gives a first good understanding regarding the influence of the inputs on the total economical impact, this analysis could not represent the reality regarding the natural variation unit of some inputs which could be more than 10%. In this sense this inputs could be assess independently considering its real dimension and unit in order to evaluate its real effect on the impact value.

More control measures

Besides all the activities and sub-activities taken into account during the development of this research and close related with the control measures applied during a dioxin incident, the MDCIM also includes other possible control activities such as the destruction of livestock which were not taken into account in this research. Consequently, the results obtained could not be valid for an incident in which this kind of control measure has been applied.

Other financial consequences

Although the model pursues to estimate all possible financial consequences of a dioxin incident, it is bounded to the direct and short term consequences of the application of control measures. In this sense, this model does not take into consideration any indirect consequence such as the financial effect of the loss of credibility or reduction of product prices that food and feed businesses could face in the long term because of the incident.

5.3 Further research

International markets of Dutch dairy products: effects on exports

Taking into consideration the strong orientation of Dutch dairy products (specifically cheese) towards external markets, and given the fact that dioxin is highly concentrated in the milk fat, two further researches are proposed:

1. The addition of a new chain stages in the model representing international markets, with the aim of measuring and predicting the possible financial consequences of the occurrence of a dioxin incident on the Dutch dairy exports.

2. The diversification of the model towards its application to other dairy products such as cheese which different from milk, involves a more complex production process, including more ingredients and international consumer markets.

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Appendices

Appendix 1. Distribution of economical impact per group of activities, sub-activities and stage of the chain

Group of activities	Stage of the chain	Sub-activity	Impact value	Percentage
Diagnostic	Feed supplier	Tracking and Tracing	-€ 500	1.34%
Diagnostic	Feed supplier	Monitoring / sampling	-€ 36,422	97.46%
Diagnostic	Feed supplier	Identifying / registering contaminated products	-€ 448	1.20%
		Total diagnostic costs for feed supplier	**-€ 37,370**	**70.96%**
Diagnostic	Farmer	Tracking and Tracing	-€ 500	4.88%
Diagnostic	Farmer	Monitoring / sampling feed	-€ 9,296	90.75%
Diagnostic	Farmer	Identifying / registering contaminated products	-€ 448	4.37%
		Total diagnostic costs for farmer	**-€ 10,244**	**19.45%**
Diagnostic	Processor	Tracking and Tracing	-€ 500	11.00%
Diagnostic	Processor	Monitoring / sampling	-€ 3,598	79.15%
Diagnostic	Processor	Identifying / registering contaminated products	-€ 448	9.85%
		Total diagnostic costs for processor	**-€ 4,546**	**8.63%**
Diagnostic	Retailer	Tracking and Tracing	-€ 500	100.00%
Diagnostic	Retailer	Monitoring / sampling	€ 0	0.00%
Diagnostic	Retailer	Identifying / registering contaminated products	€ 0	0.00%
		Total diagnostic costs for retailer	**-€ 500**	**0.95%**
Diagnostic	Entire chain	Tracking and Tracing	-€ 2,000	3.80%
		Monitoring / sampling	-€ 49,316	93.65%
		Identifying / registering contaminated products	-€ 1,344	2.55%
		Total diagnostic costs for entire chain	**-€ 52,660**	**1.74%**
Blocking business	Feed supplier	Movement standstill - Feed	-€ 25,922	100.00%
		Total blocking costs for feed supplier	**-€ 25,922**	**52.40%**
Blocking business	Farmer	Movement standstill - Animals	-€ 675	100.00%
		Total blocking costs for farmer	**-€ 675**	**1.36%**
Blocking business	Processor	Movement standstill - Milk	-€ 22,876	100.00%
		Total blocking costs for processor	**-€ 22,876**	**46.24%**
Blocking business	whole chain	Movement standstill (feed, livestock and milk)	-€ 49,473	100.00%
		Total blocking costs for the entire chain	**-€ 49,473**	**1.64%**
Recall	Feed supplier	Recalling feed	-€ 71,400	9.40%
Recall	Feed supplier	Replacing feed	-€ 687,400	90.47%
Recall	Feed supplier	Recall announcement	-€ 1,000	0.13%
		Total recall costs for feed supplier	**-€ 759,800**	**87.74%**
Recall	Processor	Recalling milk	-€ 82,440	80.67%
Recall	Processor	Recall announcement	-€ 14,000	13.70%
Recall	Processor	Consumer helping desk	-€ 3,920	3.84%
Recall	Processor	Refunding consumers	-€ 1,833	1.79%
		Total recall costs for processor	**-€ 102,193**	**11.80%**
Recall	Retailer	Recalling milk	-€ 98	2.43%
Recall	Retailer	Consumer helping desk	-€ 3,920	97.57%
		Total recall costs for retailer	**-€ 4,018**	**0.46%**
Recall	Entire chain	Recalling products (feed and milk)	-€ 153,938	17.78%
		Replacing feed	-€ 687,400	79.38%
		Recall announcement	-€ 15,000	1.73%
		Refunding consumers	-€ 1,833	0.21%
		Consumer help desk	-€ 7,840	0.91%
		Total recall costs for the entire chain	**-€ 866,011**	**28.68%**
Destruction	Feed supplier	Destroying contaminated feed	-€ 893,650	100.00%
		Total destruction costs for feed supplier	**-€ 893,650**	**43.56%**
Destruction	Farmer	Skimming raw milk	-€ 22,491	82.81%
Destruction	Farmer	Destroying raw milk and cream	-€ 4,668	17.19%
Destruction	Farmer	Destroying animals	€ 0	0.00%
Destruction	Farmer	Replacing animals	€ 0	0.00%
		Total destruction costs for farmer	**-€ 27,159**	**1.32%**
Destruction	Processor	Destroying consumption milk	-€ 536,250	47.42%
Destruction	Processor	Skimming raw milk	-€ 19,500	1.72%
Destruction	Processor	Destroying raw milk and cream	-€ 575,010	50.85%
		Total destruction costs for processor	**-€ 1,130,760**	**55.12%**
Destruction	Entire chain	Skimming raw milk	-€ 41,991	2.05%
		Destroyin contaminated products and livestock	-€ 2,009,578	97.95%
		Replacing livestock	€ 0	0.00%
		Total destruction costs for the entire chain	**-€ 2,051,569**	**67.94%**
		Total economical impact for the entire chain	**-€ 3,019,713**	

ANNEX 2. Table A: Inputs

	A	B	C	D	E
2	**Inputs**	**Formula**	**Value**	**Unit**	**Source**
4	**Labor costs**				
5	External services Tariff Labor HS	**125.00**	**125.00**	€ / hour	Intranet social sciences Group
6	External services Tariff Labor MS	**112.00**	**112.00**	€ / hour	Intranet social sciences Group
7	External services Tariff Labor LS	**65.00**	**65.00**	€ / hour	Intranet social sciences Group
8	Own employees Tariff Labor HS	**63.00**	**63.00**	€ / hour	Intranet social sciences Group
9	Own employees Tariff Labor MS	**49.00**	**49.00**	€ / hour	Intranet social sciences Group
10	Own employees Tariff Labor LS	**31.00**	**31.00**	€ / hour	Intranet social sciences Group
11	Veterinary - professional services	**102.50**	**102.50**	€ / hour	Annet Velthuis BEC
12	Veterinary - traveling costs	**17.29**	**17.29**	€ / visit	Annet Velthuis BEC
13	**External Services costs**				
14	Screening dioxin test cost	**250.00**	**250.00**	€ / sample	Ron Hoogenboom Rikilt
15	Confirmation dioxin test cost	**900.00**	**900.00**	€ / sample	Ron Hoogenboom Rikilt
16	FS Low risk material - Destruction cost	**0.09**	**0.09**	€ / kg	AVR
17	DF / MP Low risk material - Destruction cost	**0.09**	**0.09**	€ / kg	AVR
18	DF / MP High risk material - Destruction cost	**0.33**	**0.33**	€ / kg	AVR
19	DF Sacrifice - Materials costs	**20.00**	**20.00**	€/animal	Data assumed, not verified due to lack of official information
20	DF Veterinary number of visits	**1.00**	**1.00**	visits	Annet information
21	DF Cows - destruction (slaughter & incineration) cost	**11.76**	**11.76**	€ / animal	RENDAC web page costs 2009
22	DF Calves - destruction (slaughter & incineration) cost	**1.65**	**1.65**	€ / animal	RENDAC web page costs 2009
23	DF number of visits of RENDAC	**1.00**	**1.00**	visits	Annet information
24	DF / MP Milk - Skim cost	**0.08**	**0.08**	€ / kg of milk	Annet document: Distribution of Direct Recall costs along the Milk Chain
25	Placing an advertisement in national news paper -cost	**6,000.00**	**6,000.00**	€ / announcement	Annet document: Distribution of Direct Recall costs along the Milk Chain
26	Advertisement - Designing cost	**1,000.00**	**1,000.00**	€ / design	Annet document: Distribution of Direct Recall costs along the Milk Chain
27	Press release public and publication in a company`s web site	**1,000.00**	**1,000.00**	€ / publish	Annet document: Distribution of Direct Recall costs along the Milk Chain
28	FS Facility storage - renting cost	**12,000.00**	**12,000.00**	euro/month	value assumed not possible to verify
29	MP Cooling milk - energy cost	**0.01**	**0.01**	€ / kg of milk/day	http://www.cbs.nl/en-GB/menu/themas/industrie-energie/publicaties/artikelen/archief/2007/2007-2187-wm.htm
30	MP Facility storage - renting cost	**24,000.00**	**24,000.00**	€ / month	value assumed not possible to verify
31	MP Post mail stamps - refund costs	**0.44**	**0.44**	€ / unit	TNT post mail
32	**Transport costs**				
33	FS batch sample feed to lab - transport cost	**10.00**	**10.00**	€ / batch sample	http://www.tntpost.nl/zakelijk/klantenservice/English/ipb.aspx
34	DF batch sample feed to lab - transport cost	**10.00**	**10.00**	€ / batch of sample feed	http://www.tntpost.nl/zakelijk/klantenservice/English/ipb.aspx
35	DF batch sample milk to lab - transport cost	**10.00**	**10.00**	€ / batch of sample milk	http://www.tntpost.nl/zakelijk/klantenservice/English/ipb.aspx
36	MP batch sample milk to lab - transport cost	**10.00**	**10.00**	€ / batch sample	http://www.tntpost.nl/zakelijk/klantenservice/English/ipb.aspx
37	RET batch sample milk to lab - transport cost	**10.00**	**10.00**	€ / batch sample	http://www.tntpost.nl/zakelijk/klantenservice/English/ipb.aspx
38	FS feed delivered / replaced -transport cost	**0.01**	**0.01**	€ / kg	Transport cost of Annet document
39	FS feed recalled - transport cost	**0.01**	**0.01**	€ / kg	Transport cost of Annet document
40	DF milk to skim plant - transport cost	**0.05**	**0.05**	€ / kg of milk	Annet document: Distribution of Direct Recall costs along the Milk Chain
41	DF raw milk destroyed - transport costs	**0.05**	**0.05**	€ / kg of milk	Annet document: Distribution of Direct Recall costs along the Milk Chain
42	DF raw cream destroyed - transport costs	**0.05**	**0.05**	€ / kg of cream	Annet document: Distribution of Direct Recall costs along the Milk Chain
43	MP milk recalled - transport costs	**0.05**	**0.05**	€ / kg of milk	Annet document: Distribution of Direct Recall costs along the Milk Chain
44	MP milk to destruction plant- transport costs	**0.05**	**0.05**	€ / kg of milk	Annet document: Distribution of Direct Recall costs along the Milk Chain
45	MP raw cream destroyed - transport costs	**0.05**	**0.05**	€ / kg of cream	Annet document: Distribution of Direct Recall costs along the Milk Chain
46	DF animal destroyed - transport cost (RENDAC)	**10.11**	**10.11**	€ / visit	RENDAC web page costs 2009
47	DF animal repopulation - transport costs (live weight)	**0.07**	**0.07**	€ / kg	http://www.agric.nsw.gov.au/reader/cattle-transport-costs.htm
48	**Product values**				
49	FS Feed dairy cows - cost price	**=B50*0.7**	**0.15**	€ / kg	value assumed not possible to verify
50	FS Feed dairy cows - sale price / DF Feed dairy cows purchase cost	**0.22**	**0.22**	€ / kg	price of Standaard brok A of KWIN pg 160 and LEI 2008
51	DF Feed calves - cost price	**1.30**	**1.30**	€ / kg	KWIN pag 189: Mestmelk voor witvleeskalveren (per kg)
52	DF Raw milk - sale price	**0.32**	**0.32**	€ / kg of milk	LEI, Annet document and KWIN
53	MP Consump milk - cost price	**0.61**	**0.61**	€ / kg of milk	Annet document: Distribution of Direct Recall costs along the Milk Chain
54	MP Consump milk - sale price / RET Consump milk - purchase price	**0.66**	**0.66**	€ / kg of milk	Annet document: Distribution of Direct Recall costs along the Milk Chain
55	RET Consump milk - cost price	**0.69**	**0.69**	€ / kg of milk	Annet document: Distribution of Direct Recall costs along the Milk Chain
56	RET Consump milk - sale price	**0.72**	**0.72**	€ / kg of milk	Annet document: Distribution of Direct Recall costs along the Milk Chain
57	DF Cow for slaughter - sale price (market) / kg carcass	**2.06**	**2.06**	€ / kg	LEI : http://www.lei.wur.nl/UK/statistics/Agricultural+prices
58	DF Calf - sale price	**250.00**	**250.00**	€ / animal	Based on previou study: Annet Velthuis
59	DF Calf > 10 days - sale price	**225.00**	**225.00**	€ / animal	Based on previou study: Annet Velthuis
60	DF Milking cow - sale price	**817.00**	**817.00**	€ / animal	LEI : http://www.lei.wur.nl/UK/statistics/Agricultural+prices

ANNEX 2. Table A: Inputs (2)

	A	B	C	D	E
2	**Inputs**	**Formula**	**Value**	**Unit**	**Source**
61	**Stage specific activity labor hours**				
62	Risk analysis - labor hours	**20.00**	**20.00**	hour	Ron Hoogenboom Rikilt
63	FS Tracing - labor hours	**4.00**	**4.00**	hour	value assumed not possible to verify
64	DF Tracing - labor hours	**4.00**	**4.00**	hour	value assumed not possible to verify
65	MP Tracing - labor hours	**4.00**	**4.00**	hour	value assumed not possible to verify
66	RET Tracing - labor hours	**4.00**	**4.00**	hour	value assumed not possible to verify
67	FS Sampling feed- labor hours	**21.00**	**21.00**	hour	value assumed not possible to verify
68	DF Sampling feed - labor hours	**14.00**	**14.00**	hour	value assumed not possible to verify
69	DF Sampling milk - labor hours	**14.00**	**14.00**	hour	value assumed not possible to verify
70	MP Sampling milk - labor hours	**4.00**	**4.00**	hour	value assumed not possible to verify
71	RET Sampling milk - labor hours	**0.00**	**0.00**	hour	value assumed not possible to verify
72	FS Identif and regist - labor hours	**4.00**	**4.00**	hour	value assumed not possible to verify
73	DF Identif and regist - labor hours	**4.00**	**4.00**	hour	value assumed not possible to verify
74	MP Identif and regist - labor hours	**4.00**	**4.00**	hour	value assumed not possible to verify
75	RET Identif and regist - labor hours	**0.00**	**0.00**	hour	value assumed not possible to verify
76	FS Sep storage labor hours	**=IF(B103<'=25000,**	**8.00**	hour	Jan Wilkma: expert
77	FS Cent storage labor hours	**=IF(B104<'=25000,**	**8.00**	hour	Jan Wilkma: expert
78	FS feed recalled - labor hours	**1,400.00**	**1,400.00**	hour	value assumed not possible to verify
79	FS feed replaced - labor hours	**1,400.00**	**1,400.00**	hour	value assumed not possible to verify
80	MP milk recalled - labor hours	**=ROUNDUP(B119/**	**240.00**	hour	considering the same capacity and labor of a feed truck
81	MP consumer help desk - labor hours	**80.00**	**80.00**	hour	value assumed not possible to verify
82	RET milk recalled - labor hour	**2.00**	**2.00**	hour	value assumed not possible to verify
83	RET consumer help desk - labor hours	**80.00**	**80.00**	hour	value assumed not possible to verify
84	DF time required to sacrifice animal - labor hours	**0.11**	**0.11**	hour/animal	value assumed not possible to verify
85	**Stage specific samples taken and batches of samples sent to Laboratory**				
86	FS - sample feed to screening test	**100.00**	**100.00**	samples per FS	value assumed not possible to verify
87	FS - sample feed to confirmation test	**10.00**	**10.00**	samples per FS	value assumed not possible to verify
88	FS - batch sample feed	**7.00**	**7.00**	batch sample	value assumed not possible to verify
89	DF - sample feed to screening test	**5.00**	**5.00**	samples feed per DF	value assumed not possible to verify
90	DF - sample feed to confirmation test	**2.00**	**2.00**	samples feed per DF	value assumed not possible to verify
91	DF - batch sample feed	**5.00**	**5.00**	batch sample feed	value assumed not possible to verify
92	DF - sample milk to screening test	**5.00**	**5.00**	samples milk per DF	value assumed not possible to verify
93	DF - sample milk to confirmation test	**2.00**	**2.00**	samples milk per DF	value assumed not possible to verify
94	DF - batch sample milk	**1.00**	**1.00**	batch sample milk	value assumed not possible to verify
95	MP - sample milk to screening test	**5.00**	**5.00**	samples per MP	value assumed not possible to verify
96	MP - sample milk to confirmation test	**2.00**	**2.00**	samples per MP	value assumed not possible to verify
97	MP - batch sample milk	**10.00**	**10.00**	batch sample	value assumed not possible to verify
98	RET - sample milk to screening test	**0.00**	**0.00**	samples per RET	value assumed not possible to verify
99	RET - sample milk to confirmation test	**0.00**	**0.00**	samples per RET	value assumed not possible to verify
100	RET - batch sample milk	**0.00**	**0.00**	batch sample	value assumed not possible to verify
101	**Stage specific variables**				
102	FS Feed stored at operator's storage facilities	**50,000.00**	**50,000.00**	kg	assummed value to run model
103	FS Feed stored at Separated storage	**30,000.00**	**30,000.00**	kg	assummed value to run model
104	FS Feed stored at Centralized storage	**50,000.00**	**50,000.00**	kg	assummed value to run model
105	FS Feed recalled	**2,800,000.00**	**2,800,000.00**	kg	assummed value to run model : does have nothing to do with the days that are blocked
106	FS Feed replaced	**=B105**	**2,800,000.00**	kg	
107	DF Milk production	**1,666.00**	**1,666.00**	kg of milk / day	KWIN 2008-2009:
108	DF Adult feed intake	**6.50**	**6.50**	kg / animal /day	KWIN 2008-2009: page 162
109	DF Calf feed intake	**1.83**	**1.83**	kg/animal / day	KWIN 2008-2009: page 192
110	DF milking cow average weight	**568.00**	**568.00**	kg/animal	http://www.essortment.com/all/dairiescattleb_rixu.htm
111	DF cows sell to slaughter / month	**2.00**	**2.00**	animal/month	Previous studies: Annet Velthuis
112	DF calves sell to industry / month	**6.00**	**6.00**	animal/month	Previous studies: Annet Velthuis
113	DF animals not sold slaughter	**=B111*ROUNDUP(**	**2.00**	animal	
114	DF calves not sold to industry	**=B112*ROUNDUP(**	**6.00**	animal	
115	DF cows destroyed (animal > 1 year)	**0.00**	**0.00**	cows	no animals will be destroyed
116	DF calves destroyed (calf < 1 year)	**0.00**	**0.00**	calf	no calves will be destroyed
117	DF animals replaced	**=B115**	**0.00**	animal	
118	MP consump milk stored at operator's storage facilities	**150,000.00**	**150,000.00**	kg of milk	Based on Annet document of direct recall cost of milk
119	MP consump milk recalled	**1,500,000.00**	**1,500,000.00**	kg of milk	Annet document: Distribution of Direct Recall costs along the Milk Chain
120	MP consump milk sold from retailer	**=B119*0.5**	**750,000.00**	kg of milk	value assumed not verified

ANNEX 2. Table A: Inputs (3)

	A	B	C	D	E
2	**Inputs**	**Formula**	**Value**	**Unit**	**Source**
61	**Stage specific activity labor hours**				
121	MP percentage of milk refund to consumers	**0.0013**	**0.0013**	%	Annet paper of VLA
122	MP Raw milk destroyed	**150,000.00**	**150,000.00**	kg of milk	value assumed based on Annet paper
123	MP Recall announcements	**2.00**	**2.00**	announcement	Annet paper of VLA
124	RET Milk turnover	**238.00**	**238.00**	kg milk/day	value assumed not possible to verify
125	Real annual interest rate	**0.05**	**0.05**	percentage	value assumed not possible to verify
126	**Stage specific blocking time period**				
127	FS normal storage block time	**30.00**	**30.00**	day	assummed value to run the model
128	FS Sep storage block time	**30.00**	**30.00**	day	assummed value to run the model
129	FS Cent storage block time	**30.00**	**30.00**	day	assummed value to run the model
130	DF block time	**30.00**	**30.00**	day	assummed value to run the model
131	MP block time	**30.00**	**30.00**	day	assummed value to run the model
132	RET Consump milk not in stock	**5.00**	**5.00**	day	assummed value to run the model

Annex 3. Table B: Calculations

	E	F	G	H	I	J	K	L	M
137				NET COSTS (€/stage/incident)		EXTRA COSTS (€/stage/incident)			
138	**Chain stage**	**Activity**	**Sub- activity**	**Formulas**	**Net value**	**applied?**	**Description**	**Formulas**	**Value**
139	Entire chain	Diagnostic	Risk analysis	"=(Y139+U139-M139-Q139)	-€ 2,500	yes	Extra labor	'=IF(J139"="yes",B5*B62,0)	€ 2,500
140	Feed supplier	Diagnostic	Tracking and Tracing	"=(Y140+U140-M140-Q140)	-€ 500	yes	Extra labor	'=IF(J140"="yes",B5*B63,0)	€ 500
141	Feed supplier	Diagnostic	Monitoring / sampling	"=(Y141+U141-M141-Q141)	-€ 2,352	yes	Extra labor	'=IF(J141"="yes",B6*B67,0)	€ 2,352
142	Feed supplier	Diagnostic		"=(Y142+U142-M142-Q142)	-€ 70	yes	Transport - lab	'=IF(J142"="yes",B33*B88,0)	€ 70
143	Feed supplier	Diagnostic		"=(Y143+U143-M143-Q143)	-€ 25,000	yes	Lab - screening test cost	'=IF(J143"="yes",B14*B86,0)	€ 25,000
144	Feed supplier	Diagnostic		"=(Y144+U144-M144-Q144)	-€ 9,000	yes	Lab - confirmation test cost	'=IF(J144"="yes",B15*B87,0)	€ 9,000
145	Feed supplier	Diagnostic	Identifying / registering contaminated products	"=(Y145+U145-M145-Q145)	-€ 448	yes	Extra labor	'=IF(J145"="yes",B72*B6,0)	€ 448
146	Feed supplier	Blocking	Movement standstill - Feed Normal storage	"=(Y146+U146-M146-Q146)	-€ 32	yes	Rental cost	'=IF(J146"="yes",B49*B102*B125/365*B127,0)	€ 32
147	Feed supplier	Blocking	Movement standstill - Feed Separate storage	"=(Y147+U147-M147-Q147)	-€ 12,000	yes	Extra facility for storage	'=IF(J147"="yes",B28*ROUNDUP((B128/30),0),0)	€ 12,000
148	Feed supplier	Blocking		"=(Y148+U148-M148-Q148)	-€ 19	yes	Rental cost	'=IF(J148"="yes",B49*B103*B125/365*B128,0)	€ 19
149	Feed supplier	Blocking		"=(Y149+U149-M149-Q149)	-€ 520	yes	Extra labor	'=IF(J149"="yes",B7*B76,0)	€ 520
150	Feed supplier	Blocking		"=(Y150+U150-M150-Q150)	-€ 300	yes	Transport - storage place	'=IF(J150"="yes",B39*B103,0)	€ 300
151	Feed supplier	Blocking	Movement standstill - Feed Centralized storage	"=(Y151+U151-M151-Q151)	-€ 12,000	yes	Extra facility for storage	'=IF(J151"="yes",B28*ROUNDUP((B129/30),0),0)	€ 12,000
152	Feed supplier	Blocking		"=(Y152+U152-M152-Q152)	-€ 32	yes	Rental cost	'=IF(J152"="yes",B49*B104*B125/365*B129,0)	€ 32
153	Feed supplier	Blocking		"=(Y153+U153-M153-Q153)	-€ 520	yes	Extra labor	'=IF(J153"="yes",B7*B77,0)	€ 520
154	Feed supplier	Blocking		"=(Y154+U154-M154-Q154)	-€ 500	yes	Transport - storage place	'=IF(J154"="yes",B39*B104,0)	€ 500
155	Feed supplier	Recall	Recalling feed	"=(Y155+U155-M155-Q155)	-€ 28,000	yes	Transport - withdraw	'=IF(J155"="yes",B105*B39,0)	€ 28,000
156	Feed supplier	Recall		"=(Y156+U156-M156-Q156)	-€ 43,400	yes	Extra labor	'=IF(J156"="yes",B78*B10,0)	€ 43,400
157	Feed supplier	Recall	Replacing feed	"=(Y157+U157-M157-Q157)	-€ 212,800	yes	Transport - delivering	'=IF(J157"="yes",B38*B106,0)	€ 28,000
158	Feed supplier	Recall		"=(Y158+U158-M158-Q158)	-€ 43,400	yes	Extra labor	'=IF(J158"="yes",B79*B10,0)	€ 43,400
159	Feed supplier	Recall		"=(Y159+U159-M159-Q159)	-€ 431,200	yes	Feed replace - cost price	'=IF(J159"="yes",B49*B106,0)	€ 431,200
160	Feed supplier	Recall	Recall announcement	"=(Y160+U160-M160-Q160)	-€ 1,000	yes	Fixed costs design and publish in webpage	'=IF(J160"="yes",B27,0)	€ 1,000
161	Feed supplier	Destruction	Destroying contaminated feed	"=(Y161+U161-M161-Q161)	-€ 893,650	yes	Destruction cost	'=IF(J161"="yes",B16*(B102+B103+B104+B105),0)	€ 249,050
162	Feed supplier	Destruction		"=(Y162+U162-M162-Q162)	€ 0	no	Transport - destruction plant	'=IF(J162"="yes",B39*(B102+B103+B104+B105),0)	€ 0
163	Farmer	Diagnostic	Tracking and Tracing	"=Y163+U163-M163-Q163	-€ 500	yes	Extra labor	'=IF(J163"="yes",B5*B64,0)	€ 500
164	Farmer	Diagnostic	Monitoring / sampling feed	"=Y164+U164-M164-Q164	-€ 1,568	yes	Extra labor	'=IF(J164"="yes",B6*B68,0)	€ 1,568
165	Farmer	Diagnostic		"=Y165+U165-M165-Q165	-€ 50	yes	Transport - lab	'=IF(J165"="yes",B34*B91,0)	€ 50
166	Farmer	Diagnostic		"=Y166+U166-M166-Q166	-€ 1,250	yes	Lab - screening feed test cost	'=IF(J166"="yes",B14*B89,0)	€ 1,250
167	Farmer	Diagnostic		"=Y167+U167-M167-Q167	-€ 1,800	yes	Lab - confirmation feed test cost	'=IF(J167"="yes",B15*B90,0)	€ 1,800
168	Farmer	Diagnostic	Monitoring / sampling milk	"=Y168+U168-M168-Q168	-€ 1,568	yes	Extra labor	'=IF(J168"="yes",B6*B69,0)	€ 1,568
169	Farmer	Diagnostic		"=Y169+U169-M169-Q169	-€ 10	yes	Transport - lab	'=IF(J169"="yes",B94*B35,0)	€ 10
170	Farmer	Diagnostic		"=Y170+U170-M170-Q170	-€ 1,250	yes	Lab - screening milk test cost	'=IF(J170"="yes",B14*B92,0)	€ 1,250
171	Farmer	Diagnostic		"=Y171+U171-M171-Q171	-€ 1,800	yes	Lab - confirmation milk test cost	'=IF(J171"="yes",B15*B93,0)	€ 1,800
172	Farmer	Diagnostic	Identifying / registering contaminated products	"=Y172+U172-M172-Q172	-€ 448	yes	Extra labor	'=IF(J172"="yes",B73*B6,0)	€ 448
173	Farmer	Blocking	Movement standstill - animals to slaughterhouse	"=Y173+U173-M173-Q173	-€ 86	yes	Extra feed	'=IF(J173"="yes",B50*B108*B113*B130,0)	€ 86
174	Farmer	Blocking		"=Y174+U174-M174-Q174	-€ 6	yes	Rental cost	'=IF(J174"="yes",B57*(B110*0.6)*B113*B125/365*B130,0)	€ 6
175	Farmer	Blocking	Movement standstill - calves to industry	"=Y175+U175-M175-Q175	-€ 577	yes	Extra feed	'=IF(J175"="yes",B114*B109*B51*B130,0)	€ 427
176	Farmer	Blocking		"=Y176+U176-M176-Q176	-€ 6	yes	Rental cost	'=IF(J176"="yes",B58*B114*B125/365*B130,0)	€ 6
177	Farmer	Destruction	Skimming raw milk	"=Y177+U177-M177-Q177	-€ 19,992	yes	Separating milk and cream	'=IF(J177"="yes",(B107*B130)*B24,0)	€ 3,998
178	Farmer	Destruction		"=Y178+U178-M178-Q178	-€ 2,499	yes	Transport costs to processing plant	'=IF(J178"="yes",(B107*B130)*B40,0)	€ 2,499
179	Farmer	Destruction	Destroying raw milk	"=Y179+U179-M179-Q179	-€ 4,100	yes	Incineration cost milk	'=IF(J179"="yes",B17*(B107*B130)*0.965,0)	€ 4,100
180	Farmer	Destruction		"=Y180+U180-M180-Q180	€ 0	no	Transport costs to incineration plant - milk	'=IF(J180"="yes",(B107*B130)*0.965*B41,0)	€ 0
181	Farmer	Destruction	Destroying raw cream	"=Y181+U181-M181-Q181	-€ 569	yes	Incineration cost cream	'=IF(J181"="yes",B18*(B107*B130)*0.035,0)	€ 569
182	Farmer	Destruction		"=Y182+U182-M182-Q182	€ 0	no	Transport costs to incineration plant - cream	'=IF(J182"="yes",B42*(B107*B130)*0.035,0)	€ 0
183	Farmer	Destruction	Sacrificing animals	"=Y183+U183-M183-Q183	€ 0	no	Extra labor (veterinarian services)	'=IF(J183"="yes",((B11*B84*(B115+B116))+(B12*B20)),0)	€ 0
184	Farmer	Destruction		"=Y184+U184-M184-Q184	€ 0	no	Sacrifice - materials costs	'=IF(J184"="yes",(B115+B116)*B19,0)	€ 0
185	Farmer	Destruction	Destroying animals	"=Y185+U185-M185-Q185	€ 0	no	Cows - slaugther & incineration cost	'=IF(J185"="yes",B21*B115,0)	€ 0
186	Farmer	Destruction		"=Y186+U186-M186-Q186	€ 0	no	Calves - slaugther & incineration cost	'=IF(J186"="yes",B116*B22,0)	€ 0
187	Farmer	Destruction		"=Y187+U187-M187-Q187	€ 0	no	Transport costs (from farm to Rendac)	'=IF(J187"="yes",B46*B23,0)	€ 0
188	Farmer	Destruction	Replacing animals	"=Y188+U188-M188-Q188	€ 0	yes	Repopulation cost	'=IF(J188"="yes",B60*B117,0)	€ 0
189	Farmer	Destruction		"=Y189+U189-M189-Q189	€ 0	yes	Transport	'=IF(J189"="yes",B117*B110*B47,0)	€ 0

Annex 3. Table B: Calculations (2)

	E	F	G	H	I	J	K	L	M
137				NET COSTS (€/stage/incident)		EXTRA COSTS (€/stage/incident)			
138	**Chain stage**	**Activity**	**Sub- activity**	**Formulas**	**Net value**	**applied?**	**Description**	**Formulas**	**Value**
190	Processor	Diagnostic	Tracking and Tracing	''=Y190+U190-M190-Q190	-€ 500	yes	Extra labor	'=IF(J190"="yes",B5*B65,0)	€ 500
191	Processor	Diagnostic	Monitoring / sampling	''=Y191+U191-M191-Q191	-€ 448	yes	Extra labor	'=IF(J191"="yes",B70*B6,0)	€ 448
192	Processor	Diagnostic		''=Y192+U192-M192-Q192	-€ 100	yes	Transport - lab	'=IF(J192"="yes",B36*B97,0)	€ 100
193	Processor	Diagnostic		''=Y193+U193-M193-Q193	-€ 1,250	yes	Lab screening test cost	'=IF(J193"="yes",B14*B95,0)	€ 1,250
194	Processor	Diagnostic		''=Y194+U194-M194-Q194	-€ 1,800	yes	Lab confirmation test cost	'=IF(J194"="yes",B15*B96,0)	€ 1,800
195	Processor	Diagnostic	Identifying / registering contaminated products	''=Y195+U195-M195-Q195	-€ 448	yes	Extra labor	'=IF(J195"="yes",B74*B6,0)	€ 448
196	Processor	Blocking	Movement standstill - milk Normal storage	''=Y196+U196-M196-Q196	€ 0	no	Extra facility for storage	'=IF(J196"="yes",B30*ROUNDUP((B131/30),0),0)	€ 0
197	Processor	Blocking		''=Y197+U197-M197-Q197	-€ 22,500	yes	Extra energy	'=IF(J197"="yes",B118*B29*B131,0)	€ 22,500
198	Processor	Blocking		''=Y198+U198-M198-Q198	-€ 376	yes	Rental costs	'=IF(J198"="yes",(B53*B118*B125/365)*B131,0)	€ 376
199	Processor	Recall	Recall announcement	''=Y199+U199-M199-Q199	-€ 14,000	yes	Media announcement costs	'=IF(J199"="yes",(B25*B123)+B26+B27,0)	€ 14,000
200	Processor	Recall	Recalling milk	''=Y200+U200-M200-Q200	-€ 75,000	yes	Transport costs	'=IF(J200"="yes",B43*B119,0)	€ 75,000
201	Processor	Recall		''=Y201+U201-M201-Q201	-€ 7,440	yes	Extra labor	'=IF(J201"="yes",B80*B10,0)	€ 7,440
202	Processor	Recall	Consumer helping desk	''=Y202+U202-M202-Q202	-€ 3,920	yes	Extra labor	'=IF(J202"="yes",B81*B9,0)	€ 3,920
203	Processor	Recall	Refunding consumers	''=Y203+U203-M203-Q203	-€ 1,833	yes	Total refund	'=IF(J203"="yes",(B120*B121*((B56*2)+B31)),0)	€ 1,833
204	Processor	Destruction	Destroying consumption milk	''=Y204+U204-M204-Q204	-€ 536,250	yes	Destruction cost consumption milk	'=IF(J204"="yes",B18*(B118+B119),0)	€ 536,250
205	Processor	Destruction		''=Y205+U205-M205-Q205	€ 0	no	Transport cost consump milk	'=IF(J205"="yes",B43*(B118+B119),0)	€ 0
206	Processor	Destruction	Skimming raw milk	''=Y206+U206-M206-Q206	-€ 7,500	yes	Transport - processing plant	'=IF(J206"="yes",B122*B43,0)	€ 7,500
207	Processor	Destruction		''=Y207+U207-M207-Q207	-€ 12,000	yes	Skim process cost	'=IF(J207"="yes",B24*B122,0)	€ 12,000
208	Processor	Destruction	Destroying raw milk	''=Y208+U208-M208-Q208	-€ 561,000	no	Transport - destruction plant	'=IF(J208"="yes",B44*B122*0.965,0)	€ 0
209	Processor	Destruction		''=Y209+U209-M209-Q209	-€ 12,304	yes	Destruction cost	'=IF(J209"="yes",B17*B122*0.965,0)	€ 12,304
210	Processor	Destruction	Destroying raw cream	''=Y210+U210-M210-Q210	€ 0	no	Transport - destruction plant	'=IF(J210"="yes",B122*0.035*B45,0)	€ 0
211	Processor	Destruction		''=Y211+U211-M211-Q211	-€ 1,706	yes	Destruction cost	'=IF(J211"="yes",B122*0.035*B18,0)	€ 1,706
212	Retailer	Diagnostic	Tracking and Tracing	''=Y212+U212-M212-Q212	-€ 500	yes	Extra labor	'=IF(J212"="yes",B66*B5)	€ 500
213	Retailer	Diagnostic	Monitoring / sampling	''=Y213+U213-M213-Q213	€ 0	yes	Extra labor	'=IF(J213"="yes",B6*B71,0)	€ 0
214	Retailer	Diagnostic		''=Y214+U214-M214-Q214	€ 0	yes	Transport - lab	'=IF(J214"="yes",B37*B100,0)	€ 0
215	Retailer	Diagnostic		''=Y215+U215-M215-Q215	€ 0	yes	Lab screening test cost	'=IF(J215"="yes",B14*B98,0)	€ 0
216	Retailer	Diagnostic		''=Y216+U216-M216-Q216	€ 0	yes	Lab confirmation test cost	'=IF(J216"="yes",B15*B99,0)	€ 0
217	Retailer	Diagnostic	Identifying / registering contaminated products	''=Y217+U217-M217-Q217	€ 0	yes	Extra labor	'=IF(J217"="yes",B75*B6,0)	€ 0
218	Retailer	Recall	Recalling milk	''=Y218+U218-M218-Q218	-€ 98	yes	Extra labor	'=IF(J218"="yes",B82*B10,0)	€ 62
219	Retailer	Recall	Consumer helping desk	''=Y219+U219-M219-Q219	-€ 3,920	yes	Extra labor	'=IF(J219"="yes",B83*B9,0)	€ 3,920
220			**TOTAL IMPACT (net costs)**	**''=SUM(H139:H219)**	**-€ 3,022,213**		**TOTAL IMPACT (extra costs)**	**'=SUM(M139:M219)**	**€ 1,615,634**

Annex 3. Table B: Calculations (3)

	E	F	G	H	I	N	O	P	Q
137				NET COSTS (€/stage/incident)		RETURNS FORGONE (€/stage/incident)			
138	**Chain stage**	**Activity**	**Sub- activity**	**Formulas**	**Net value**	**applied?**	**Description**	**Formulas**	**Value**
139	Entire chain	Diagnostic	Risk analysis	"=(Y139+U139-M139-Q139)	-€ 2,500				
140	Feed supplier	Diagnostic	Tracking and Tracing	"=(Y140+U140-M140-Q140)	-€ 500				
141	Feed supplier	Diagnostic	Monitoring / sampling	"=(Y141+U141-M141-Q141)	-€ 2,352				
142	Feed supplier	Diagnostic		"=(Y142+U142-M142-Q142)	-€ 70				
143	Feed supplier	Diagnostic		"=(Y143+U143-M143-Q143)	-€ 25,000				
144	Feed supplier	Diagnostic		"=(Y144+U144-M144-Q144)	-€ 9,000				
145	Feed supplier	Diagnostic	Identifying / registering contaminated products	"=(Y145+U145-M145-Q145)	-€ 448				
146	Feed supplier	Blocking	Movement standstill - Feed Normal storage	"=(Y146+U146-M146-Q146)	-€ 32				
147	Feed supplier	Blocking	Movement standstill - Feed Separate storage	"=(Y147+U147-M147-Q147)	-€ 12,000				
148	Feed supplier	Blocking		"=(Y148+U148-M148-Q148)	-€ 19				
149	Feed supplier	Blocking		"=(Y149+U149-M149-Q149)	-€ 520				
150	Feed supplier	Blocking		"=(Y150+U150-M150-Q150)	-€ 300				
151	Feed supplier	Blocking	Movement standstill - Feed Centralized storage	"=(Y151+U151-M151-Q151)	-€ 12,000				
152	Feed supplier	Blocking		"=(Y152+U152-M152-Q152)	-€ 32				
153	Feed supplier	Blocking		"=(Y153+U153-M153-Q153)	-€ 520				
154	Feed supplier	Blocking		"=(Y154+U154-M154-Q154)	-€ 500				
155	Feed supplier	Recall	Recalling feed	"=(Y155+U155-M155-Q155)	-€ 28,000				
156	Feed supplier	Recall		"=(Y156+U156-M156-Q156)	-€ 43,400				
157	Feed supplier	Recall	Replacing feed	"=(Y157+U157-M157-Q157)	-€ 212,800	yes	Margin lost for feed replaced	=IF(N157'="yes",(B50-B49)*B106,0)	€ 184,800.00
158	Feed supplier	Recall		"=(Y158+U158-M158-Q158)	-€ 43,400				
159	Feed supplier	Recall		"=(Y159+U159-M159-Q159)	-€ 431,200				
160	Feed supplier	Recall	Recall announcement	"=(Y160+U160-M160-Q160)	-€ 1,000				
161	Feed supplier	Destruction	Destroying contaminated feed	"=(Y161+U161-M161-Q161)	-€ 893,650	yes	Feed contam. Not sold and recalled	=IF(N161'="yes",B50*(B102+B103+B104+B105),0)	€ 644,600.00
162	Feed supplier	Destruction		"=(Y162+U162-M162-Q162)	€ 0				
163	Farmer	Diagnostic	Tracking and Tracing	"=Y163+U163-M163-Q163	-€ 500				
164	Farmer	Diagnostic	Monitoring / sampling feed	"=Y164+U164-M164-Q164	-€ 1,568				
165	Farmer	Diagnostic		"=Y165+U165-M165-Q165	-€ 50				
166	Farmer	Diagnostic		"=Y166+U166-M166-Q166	-€ 1,250				
167	Farmer	Diagnostic		"=Y167+U167-M167-Q167	-€ 1,800				
168	Farmer	Diagnostic	Monitoring / sampling milk	"=Y168+U168-M168-Q168	-€ 1,568				
169	Farmer	Diagnostic		"=Y169+U169-M169-Q169	-€ 10				
170	Farmer	Diagnostic		"=Y170+U170-M170-Q170	-€ 1,250				
171	Farmer	Diagnostic		"=Y171+U171-M171-Q171	-€ 1,800				
172	Farmer	Diagnostic	Identifying / registering contaminated products	"=Y172+U172-M172-Q172	-€ 448				
173	Farmer	Blocking	Movement standstill - animals to slaughterhouse	"=Y173+U173-M173-Q173	-€ 86				
174	Farmer	Blocking		"=Y174+U174-M174-Q174	-€ 6				
175	Farmer	Blocking	Movement standstill - calves to industry	"=Y175+U175-M175-Q175	-€ 577	yes	Margin lost calves > 10 days	=IF(N175'="yes",(B58-B59)*B114,0)	€ 150.00
176	Farmer	Blocking		"=Y176+U176-M176-Q176	-€ 6				
177	Farmer	Destruction	Skimming raw milk	"=Y177+U177-M177-Q177	-€ 19,992	yes	Milk contam. Not sold	=IF(N177'="yes",B52*B107*B130,0)	€ 15,993.60
178	Farmer	Destruction		"=Y178+U178-M178-Q178	-€ 2,499				
179	Farmer	Destruction	Destroying raw milk	"=Y179+U179-M179-Q179	-€ 4,100				
180	Farmer	Destruction		"=Y180+U180-M180-Q180	€ 0				
181	Farmer	Destruction	Destroying raw cream	"=Y181+U181-M181-Q181	-€ 569				
182	Farmer	Destruction		"=Y182+U182-M182-Q182	€ 0				
183	Farmer	Destruction	Sacrificing animals	"=Y183+U183-M183-Q183	€ 0				
184	Farmer	Destruction		"=Y184+U184-M184-Q184	€ 0				
185	Farmer	Destruction	Destroying animals	"=Y185+U185-M185-Q185	€ 0	no	Cows contam. Not sold to slaughter	=IF(N185'="yes",B57*(B110*0.6)*B115,0)	€ 0.00
186	Farmer	Destruction		"=Y186+U186-M186-Q186	€ 0	no	Calves contam. Not sold	=IF(N186'="yes",B58*B116,0)	€ 0.00
187	Farmer	Destruction		"=Y187+U187-M187-Q187	€ 0				
188	Farmer	Destruction	Replacing animals	"=Y188+U188-M188-Q188	€ 0				
189	Farmer	Destruction		"=Y189+U189-M189-Q189	€ 0				

Annex 3. Table B: Calculations (4)

	E	F	G	H	I	N	O	P	Q
137				NET COSTS (€/stage/incident)		RETURNS FORGONE (€/stage/incident)			
138	**Chain stage**	**Activity**	**Sub- activity**	**Formulas**	**Net value**	**applied?**	**Description**	**Formulas**	**Value**
190	Processor	Diagnostic	Tracking and Tracing	"=Y190+U190-M190-Q190	-€ 500				
191	Processor	Diagnostic	Monitoring / sampling	"=Y191+U191-M191-Q191	-€ 448				
192	Processor	Diagnostic		"=Y192+U192-M192-Q192	-€ 100				
193	Processor	Diagnostic		"=Y193+U193-M193-Q193	-€ 1,250				
194	Processor	Diagnostic		"=Y194+U194-M194-Q194	-€ 1,800				
195	Processor	Diagnostic	Identifying / registering contaminated products	"=Y195+U195-M195-Q195	-€ 448				
196	Processor	Blocking	Movement standstill - milk Normal storage	"=Y196+U196-M196-Q196	€ 0				
197	Processor	Blocking		"=Y197+U197-M197-Q197	-€ 22,500				
198	Processor	Blocking		"=Y198+U198-M198-Q198	-€ 376				
199	Processor	Recall	Recall announcement	"=Y199+U199-M199-Q199	-€ 14,000				
200	Processor	Recall	Recalling milk	"=Y200+U200-M200-Q200	-€ 75,000				
201	Processor	Recall		"=Y201+U201-M201-Q201	-€ 7,440				
202	Processor	Recall	Consumer helping desk	"=Y202+U202-M202-Q202	-€ 3,920				
203	Processor	Recall	Refunding consumers	"=Y203+U203-M203-Q203	-€ 1,833				
204	Processor	Destruction	Destroying consumption milk	"=Y204+U204-M204-Q204	-€ 536,250				
205	Processor	Destruction		"=Y205+U205-M205-Q205	€ 0				
206	Processor	Destruction	Skimming raw milk	"=Y206+U206-M206-Q206	-€ 7,500				
207	Processor	Destruction		"=Y207+U207-M207-Q207	-€ 12,000				
208	Processor	Destruction	Destroying raw milk	"=Y208+U208-M208-Q208	-€ 561,000	yes	Consumption milk destroyed	=IF(N208="yes",(B118+B119)*(B54-B52),0)	€ 561,000.00
209	Processor	Destruction		"=Y209+U209-M209-Q209	-€ 12,304				
210	Processor	Destruction	Destroying raw cream	"=Y210+U210-M210-Q210	€ 0				
211	Processor	Destruction		"=Y211+U211-M211-Q211	-€ 1,706				
212	Retailer	Diagnostic	Tracking and Tracing	"=Y212+U212-M212-Q212	-€ 500				
213	Retailer	Diagnostic	Monitoring / sampling	"=Y213+U213-M213-Q213	€ 0				
214	Retailer	Diagnostic		"=Y214+U214-M214-Q214	€ 0				
215	Retailer	Diagnostic		"=Y215+U215-M215-Q215	€ 0				
216	Retailer	Diagnostic		"=Y216+U216-M216-Q216	€ 0				
217	Retailer	Diagnostic	Identifying / registering contaminated products	"=Y217+U217-M217-Q217	€ 0				
218	Retailer	Recall	Recalling milk	"=Y218+U218-M218-Q218	-€ 98	yes	Milk sale loses	=IF(N218="yes",((B56-B55)*B132*B124),0)	€ 35.70
219	Retailer	Recall	Consumer helping desk	"=Y219+U219-M219-Q219	-€ 3,920				
220			**TOTAL IMPACT (net costs)**	**"=SUM(H139:H219)**	**-€ 3,022,213**		**TOTAL IMPACT (retunrs forgone)**	**=SUM(Q139:Q219)**	**€ 561,035.70**

ANNEX 4. Table C: Impact Dimension

	E	F	G	I	J	K	L
3		**Impact value / stage**		**Number of business contaminated**		**TOTAL IMPACT**	
4	**Chain stages**	**Formula**	**Value**	**Formula**	**Value**	**Formula**	**Value**
5	Feed supplier	=SUM(H140:H162)	-€ 1,716,742	1	1	=F5*I5	-€ 1,716,742
6	Dairy Farm	=SUM(H163:H189)	-€ 38,078	=IF(I5*25*J11>350*I5,350*I5,I5*25*J11)	75	=F6*I6	-€ 2,855,844
7	Milk Processor	=SUM(H190:H211)	-€ 1,260,375	=IF(I6<75,0,1)*IF(I6'=75,3,1)*IF(I6'=100,4,1)*IF(I6'=125,5,1)*IF(I6'=150,6,1)*IF(I6'=175,7,1)*IF(I6'=200,8,1)*IF(I6'=225,9,1)*IF(I6'=250,10,1)*IF(I6'=275,11,1)*IF(I6'=300,12,1)*IF(I6'=325,13,1)*IF(I6'=350,14,1)	3	=F7*I7	-€ 3,781,125
8	Retailer	=SUM(H212:H219)	-€ 4,518	=I7*63	189	=F8*I8	-€ 853,845
9	**Net Impact**	**=SUM(H5:H8)**	**-€ 3,019,713**	**Net impact**		**=SUM(K5:K8)**	**-€ 9,207,556**
10							
11				**Number of days after beginning of contamination**	3		
12							
13	Risk Analysis cost	=H139	-€ 2,500	Risk Analysis cost		=F139	-€ 2,500
14	**Total impact**	**=+F13+F9**	**-€ 3,022,213**	**Total Impact**		**=+K13+K9**	**-€ 9,210,056**